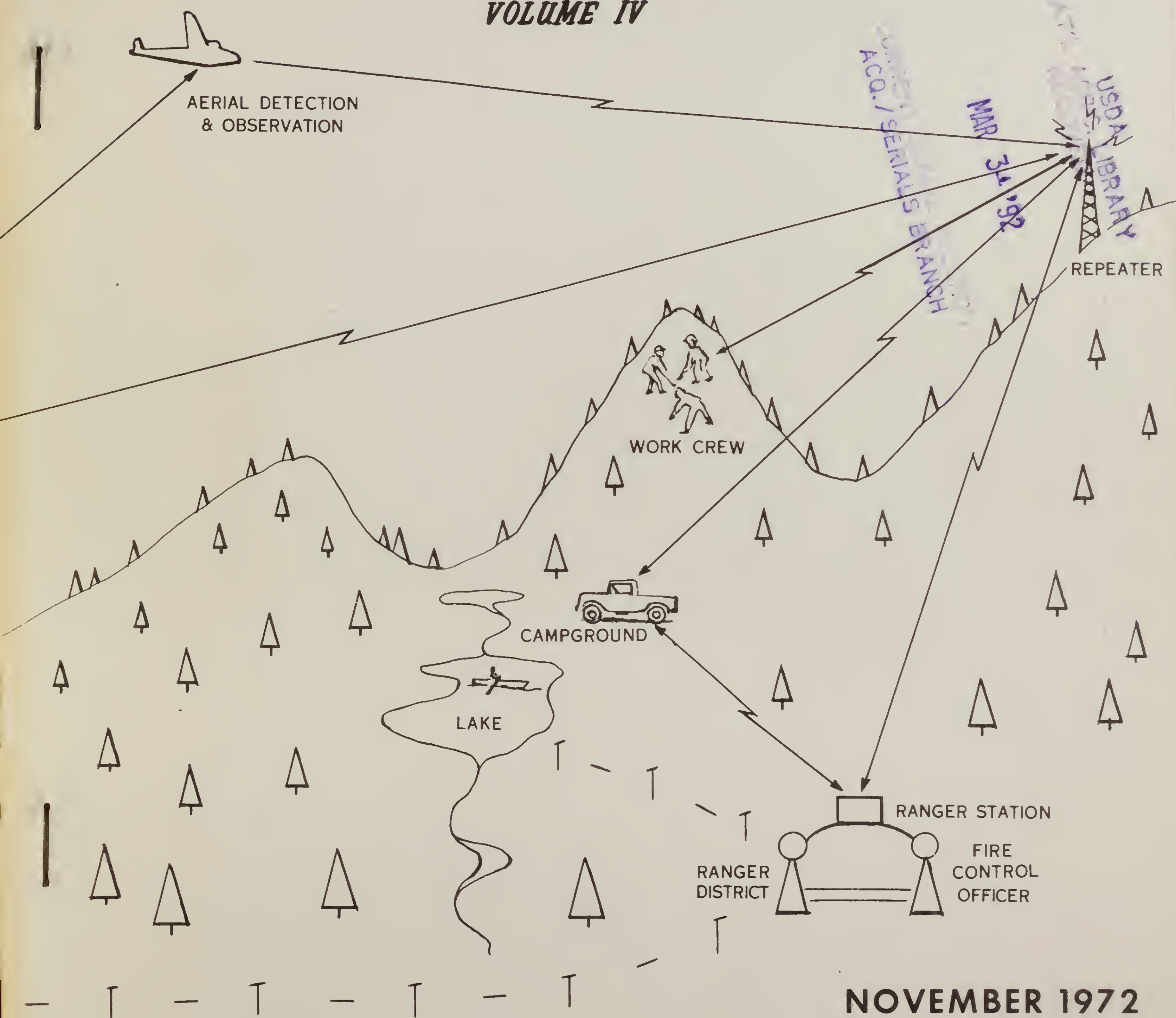
A STUDY OF
FOREST SERVICE

TELECOMMUNICATIONS

VOLUME IV



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FOREST SERVICE TELECOMMUNICATIONS STUDY

Volume IV

Large Fire Communications System

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GLOSSARY

air net	present radio communications network designed to provide air to air and air to ground communications for Forest Service and Forest Service contract aircraft. They are often designed on a regional basis.
amplitude modulated (AM)	the magnitude of the radio wave is varied in accordance with the information to be transmitted or exchanged.
associated single-frequency channel	associated with each repeater pair of frequencies is a channel that has a transmitter frequency identical to the receive frequency of field radios that use the repeater channel. Most Forest network radios are so equipped. Local communications can be accomplished over the associated single-frequency channel that would not tie up the entire repeater system.
crystal controlled	radios in which each operating frequency is determined and controlled by a vibrating quartz crystal. This limits the number of channels available because of the physical size of the crystals required.
communications channel	similar to a radio frequency, but more general. It is a medium over which communications are established and carried out.
communications link	established communications between two parties. Example: Fire boss to line boss.
communications network	a combination of links that are complete as to some specific function. Examples: A network to serve command personnel; a network to serve air to air control.

communications system - - - - - a combination of links or networks that serve a general function. Example: Ground attack communications system made up of command, tactical, service, and intra-camp networks.

forest net- - - - - - - - - - - - a radio communications network designed to provide forest-wide communications. They are designed for the specific forest requirements.

frequency modulated (FM)- - - - the frequency of the radio wave is varied in accordance with the information to be transmitted or exchanged.

high band VHF - - - - - - - - - radio frequencies from 142 to 174 MHz.

rotary (Hunting) system call routing - - - - - - - allows incoming calls to hunt for a free line among all those lines assigned to the subscriber. Calls can be held until parties otherwise tied up have an opportunity to answer the call.

low band VHF- - - - - - - - - - radio frequencies from 30 - 50 MHz.

megahertz (MHz) - - - - - - - - this is a common technical term that refers to the frequency of the radio wave. 1 MHz = 1,000,000 cycles per second or hertz.

multicom aircraft radios- - - - these are AM radios, using all channel selection techniques, used in most public and private aircraft. These radios have been available for years.

propagation characteristics - - these describe how effectively a radio wave is transmitted from one place to another. For example, UHF and high band VHF have line of sight characteristics similar to optical propagation.

repeater channel- - - - - - - - a two-frequency channel that uses an intermediate repeater to extend the range of the channel. The repeater unit simultaneously receives on one frequency and transmits on another. It is inefficient in that two discrete frequencies are required to establish one communications channel.

single-frequency channel- - - - a channel which is direct from transmitter to receiver. Transmitter and receiver frequencies are identical.

slow speed facsimile- - - - - - facsimile is the process whereby images (either print or picture) are translated into electrical signals, transmitted over a communications link, and re-constituted at the receiving end into the original image. Slow speed facsimile uses voice grade (300-3000 Hz) communication links, and consequently takes about 2 minutes to transmit a 8"x10" page.

telephone patch - - - - - - - - - a device that allows a radio to be used as an entrance and exit point from the commercial telephone system.

ultra high frequency (UHF) - - - radio frequencies from 300 MHz to 3000 MHz. The upper portion, from about 1000 to 3000 MHz, is often referred to as low capacity microwave. The Forest Service is interested in the 400 to 420 MHz range.

INTRODUCTION

A. GENERAL STUDY OBJECTIVE

This study is principally concerned with communication needs during fires which have grown to project size or during multiple fire situations requiring a project organization. While large fire communications are the primary concern of this study, the proposed communication system designs must, where possible, take into account the needs of the initial attack situation. The overall design must provide the flexibility for an orderly transition from initial attack through the build-up phase to the large fire situation. The study recommendations incorporate non-large fire considerations. This is especially true in the case of the communication requirements in Southern California and air attack communications. In general, the proposed air attack communications system is intended to serve the needs of both the project and non-project fire situations. To this extent, the evaluation of the benefits of the proposed alternatives, on which the recommendations are based, includes non-large fire benefits.

In a wider context, the emphasis in fire suppression is and must be on controlling fires while they are small. Accordingly, emphasis must remain on building and maintaining adequate forest communication systems capable of providing the necessary response times (on the ground and in the air) to halt fires before they attain unmanageable proportions. Past experience has shown, however, that despite the best efforts of the fire suppression organization, there will be circumstances when fires will not be contained in the initial stages. The study recommendations are framed in the light of these circumstances.

The general criteria of a desirable fire communications system guiding the study group were:

1. Operational reliability of the system under varying uses and conditions.

2. Minimum number of communication network interfaces.

3. Flexibility of use and system adaptability.

4. Capacity to accommodate the generated traffic load with some excess capacity for emergency needs.

5. Systems ready for use when needed at costs commensurate with the expected gains.

The study also attempted to reconcile, within practical limits, two mutually exclusive functions of all Forest Service fire communications systems:

- Provision for a common communications link, for safety purposes, between all parties in urgent need of such a link.

- Provision for separate communication links for use in direct support of specific tasks (including coordination).

One of the difficulties associated with the above dual function of a communication system is the frequent need for simultaneous monitoring, that is, the ability to listen simultaneously to more than one communications network. Under the usual fluid fire suppression situation, this imposes severe practical limitations on the communications system design, especially if coupled with the need for operational simplicity.

B. HISTORICAL NOTE AND STUDY BACKGROUND

Historical dissatisfaction with large fire communications on the part of fire control personnel has (since 1962) led sequentially to: 1) a pilot forest net communications study under fire and non-fire conditions, 2) a Forest Service Communications Study Task Force convened in 1968, and 3) the present Large Fire Communications Study.

The Task Force of 1968 provided a preliminary general problem identification and study outline which provided the departure point of the present study. The Task Force recommendations and the Study Plan were based on reported communication deficiencies. These were documented in numerous fire control memoranda, reports and studies. These documents identify the specific problem areas dealt with in this study. Following are a few direct quotations:

1. From a report dated 3/67, entitled, Guidelines for Developing and Field Testing the Universal Intra-sector Fire Net, (Page 1, Par. 2 of report): "Nowadays, for the Sector Boss to direct his unit is indeed a challenge, and dependable communications is his most useful tool. Unfortunately, communications has not kept pace with demand."

2. From a fire control report to the Office of Emergency Planning, dated 3/67, entitled, Communication in the Fire Services, (Page 1, Par. 1 of report): "More than any other support activity, successful control of forest, brush, and grass fires depends on communications."

3. (Same document, Page 1, Par. 5 of report): "Some inadequacy of communications is often blamed for fire fighter casualties and failure to meet standards of fire control."

4. From a study proposal, dated 7/67, entitled, Forest Fire Suppression Communications, (Page 1, Par. 2 of report): "...developments in communications capability has not kept pace with modernization of fire attack forces."

The specific large fire communications areas identified for intensive study were determined with the direct participation of the division of fire control and were based, in part, on these and other reports.

The major problems identified for study were:

1. Lack of intra-sector communications and direct sector communications to air attack (especially helicopters).

2. Congestion and interference in aspects of air attack communications (dispatching, air control over the fire, and ground attack coordination).

3. Congested service communications.

4. Problems in obtaining proper equipment from the various regional caches that would fit together into a complete fire communications network.

These major problems and several others (fire communications management, etc.) were studied and, we believe, can be resolved by the implementation of the recommendations incorporated in this report.

C. SPECIAL ACKNOWLEDGEMENT

A full roster of participants in the fire study can be found in Volume I of the Forest Service Telecommunications Study.

The study team would like to acknowledge the aid provided by individuals in Fire Control. In particular, mention must be made of the highly cooperative attitude of the fire fighting personnel during the 1970 conflagrations in the western United States and the Large Fire Questionnaire respondents.

The cooperation of these and others involved in the study is much appreciated.

D. DATA SOURCES

The analysis of the large fire communication needs was based on direct recordings of fire communications, questionnaire data, submitted written opinions from the field, and interview data. The field data were gathered in 1970 during multi-division fires in Regions 2, 3, 5, and 6. The list of fires is shown in Table A1 of the appendix (page A1).

Study teams observed the communication function on going project fires by direct monitoring and by use of portable recorders placed in lead planes, dispatchers' offices and at strategic locations around the fire lines. Detailed instructions for this data collection process were set forth in the study plan.

The list of tapes transcribed and analyzed for the study are shown in Table A2 of the appendix (page A3).

Large Fire Communication Questionnaire

Experienced fire overhead from all nine regions were asked to complete the questionnaire shown in the appendix, Exhibit B1 (page A38). Over four hundred completed questionnaires were received. These were distributed between regions and among overhead positions as shown in Tables 1 and 2, pages 7 and 8.

Indicative of the respondents' fire qualifications, 74% of the fire bosses and 97% of the crew bosses had fire experience in 1970.

Table 1. Regional distribution of large fire questionnaire respondents.

Region	Percent of Responses
1	12
2	11
3	15
4	13
5	17
6	19
8	9
9	3
10	1

Table 2. Large fire questionnaire respondents classed according to their fire overhead designation.

Position	No.	Position	No.
Fire Bosses	22	Air Service Officers	9
Line Bosses	21	Air Dispatchers	16
Air Attack Bosses	17	Helicopter Bosses	17
Division Bosses	27	Tractor Bosses	19
Sector Bosses	35	Tanker Bosses	13
Crew Bosses (Inter-regional or Special)	29	Service Chiefs	15
Chief Pilot	3	Plans Chief	24
Lead Pilots (Air Tanker Bosses)	19	Line Scout	13
Fire Behavior Officers	10	Public Information Officer	14
Communications Officers	14	Safety Officers	10
Liaison Officers	8	Supply Officers	20
		Forest Dispatchers	26
		TOTAL	401

PART I

CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY OF LARGE FIRE COMMUNICATIONS SYSTEM REQUIREMENTS

1. Emergency Communication Requirements

In emergency situations, fire line personnel assigned communications equipment must be able to communicate directly with air support and with other ground personnel who can reasonably provide help.

2. Command Communication Requirements

The fire boss, line boss, air attack boss and air tanker boss (air tanker pilot in his absence), helicopter boss and division bosses need direct, reliable communications with each other, the fire camp, and spike camps. This "command channel," must provide transmission capabilities between points along the entire fire perimeter and must include provisions for communicating over rough terrain.

3. Command Channel Utilization Requirements

The command channel must remain uncongested. The total number of airborne and ground stations assigned to this channel on a multi-division fire, including all those enumerated under Item 2, should not exceed twenty.

4. Command Channel Separation Requirements

A minimum of three command channels are needed on a nationwide basis to allow the separation of simultaneous fire communications within the radius of ground radio interference. Different command channels must be clearly marked for easy identification.

5. Tactical Communication Requirements

A minimum of three tactical channels are required to provide intra-division communication links between division, sector and crew bosses, and various specialists at sector and crew levels. Line-air coordination with helicopters must also be accommodated by these channels.

6. Air to Air Communication Requirements

A minimum of four, and more adequately six, non-repeater air to air communication channels for close range communications are required to separate areas of concurrent sustained slurry drop operations within radio interference distances.

7. Simultaneous Monitoring Requirements

The air attack boss and/or the air tanker boss and helicopters require simultaneous monitoring of the fire line to air and the air to air communications traffic. Instrumentation for simultaneous monitoring is required. Air tankers require air to air communications when operating under the direction of an air tanker boss or air attack boss and air to ground communications otherwise, but do not require simultaneous monitoring capability.

No person, without the support of a special radio operator, should have more than two "work channels" with simultaneous monitoring requirements. A "work channel" is one used in direct support of a specific activity.

8. Long-Range Air Communication Requirements

A long range communication channel is required for all fixed wing aircraft to serve as a communication link between the air dispatcher, air base, slurry base, and the aircraft.

A national standby channel, for use by all aircraft not temporarily assigned to a different channel, must be designated from among the available air communication channels.

9. Service Radio Communication Requirements

A single high quality service radio communication channel from fire headquarters to "outside" is required if adequate telephone service (including radio telephone) is not available. Verbal relays are not acceptable. A transmission range of forty to sixty miles is required. The service channel should be available with arrival of project overhead. Hard copy transmission equipment for transmitting lengthy messages such as supply orders and fire progress reports is required with either radio or telephone communication links.

10. Fire Camp Communication Requirements

A short range intra-camp communications system is needed between the functional groups of plans, service and finance. When there is too much physical separation between service and its subunits such as the motor pool, supply officer or camp officer, the system should be capable of being extended to them. Spike camps staffed with full time service personnel need a communication channel to the main fire headquarters.

11. Service Communication Management Requirements

Service communication management needs to provide:

a. Trained operators.

b. Clear and concise operating instructions for fire camp communications equipment.

c. Emergency step-up plans for the Supervisor's Office message handling capabilities.

12. Fire Cache Composition Requirements

A national fire cache must be able to supply fifteen multi-division or multiple fires, simultaneously. Equipment is required to properly operate and control the ground communications system, and to implement the air communications system in unequipped aircraft. A three-day supply of batteries should accompany each module. The arrival of fire cache radio equipment on the fire should coincide with the arrival of the intended users (project overhead).

13. Equipment Standardization Requirements

Communication equipment in a national cache system needs to be standardized to facilitate use and to minimize different types of batteries and other replacement parts needed at the fire. All fire communications equipment must be clearly marked for easy identification.

14. Fire Communication Management Requirements

The overall management of the fire communication system including assignment of channels and monitoring of the system must be under the control of a designated individual with an understanding of the communication system and of the fire communication needs.

Figure 1, page 14, is a schematic outline of the requirements. This outline should help clarify the implications of the requirements for the large fire radio system.

In addition to the above requirements, the study identified a special initial attack requirement for Southern California:

Southern California Cooperator and Ground Tanker Communication Requirements

Improved communications between cooperator overhead (fire chiefs and battalion commanders) and Forest Service fire overhead during initial fire attack on four forests in Southern California are necessary. Communications between fire overhead and ground tankers dispatched to the fire from other national forests in Southern California are also required.

Figure 1. Schematic outline of large fire communications requirements

Legend:

C - Command Network (with repeater)
T - Tactical Network
A - Air to Air Network
L - Long Range Air Network (with repeater)
S - Service Network (with repeater)
I - Intra-Camp Network
VHF - Air Emergency Network (one FAA channel to be used only for air emergency)

Place or Position	Requirements		System Implications	
	"Working Net(s)"	Available "Sec. Net(s)"	Required No./Radios	No. Simultaneous Working Nets
Fire Camp	C,S,I	T	3	3
Spike Camp	C or T		1	1
Fire Boss	C	T	1	1
Line Boss	C	T	1	1
Division Boss	C or T		1	1
Sector Boss	T	C	1	1
Crew Boss	T	C	1	1
Special Functions (i.e.,Firing Boss, Tractor Boss,etc.)	T	C	1	1
Heliport	C or T		1	1
Helispot	C or T		1	1
Air Attack Boss	C,A,L	T,VHF	2	3
Helicopter Boss	C or T		1	1
Air Tanker Boss	C,A or L	T,VHF	2	2
Air Tankers	A or L	C,T,VHF	1	1
Helicopters	T,A	C,L,VHF	2	2
Air Dispatchers	L		1	1
Air/Slurry Base	L		1	1
Dispatcher	S		1	1
General Headqts.	S		1	1

B. LARGE FIRE SYSTEM DESIGN RECOMMENDATIONS

Large fire communications system recommendations are discussed in the following order:

- Ground attack communications (command and tactical networks)
- Air attack communication (air to air network)
- Long-range air communications
- Service communications
- Intracamp communications
- Communications management

GROUND ATTACK COMMUNICATION SYSTEM

Objective: Interference-free and reliable communications:

- among top command personnel, division boss and above (Requirements No. 1, 2, 3 and 4)
- between top command personnel and all associated fire camps (Requirement No. 2)
- within a division and sector (Requirements No.1 and 5)
- between ground and fixed wing aircraft or helicopters for coodination and ground personnel safety (Requirements No. 1, 2 and 5)

Recommendations

1. Provide two ground communication networks, as follows:

   a. A command network to serve division boss and above (including air attack boss and air tanker boss, for fire line to air attack boss and air tanker boss, for fire line to air coordination requirements), fire camp, spike camps and heliports.

   b. A tactical network to serve sector boss and below (including helicopters).

   (See Recommendation 15, Vol. 1, page 31.)

2. The command network should consist of three repeater channels (and three repeater associated single-frequency channels); the tactical network should consist of three single-frequency channels.

3. The command and tactical networks should be contained in a single radio requiring, in effect, nine channels and nine frequencies. (For the interim, three different five-channel radios could be used if necessary. Each of the five-channel radios would include one of the command channels, its associated single-frequency channel, and all three tactical channels.)

4. The Division Boss should serve as the primary interface between the two networks.

5. The ground attack system should be cached in a National Radio Cache System.

Figure 2, page 23, shows, schematically, the recommended large fire ground attack radio system. Figure 3, page 24, provides an operational illustration of the system.

AIR ATTACK COMMUNICATION SYSTEM

Objective: Interference-free and reliable communications between:

- aircraft for air attack control operations (Requirements No. 6 and 7)
- aircraft and ground personnel for coordination of air and ground attack and personnel safety (Requirements No. 1, 2 and 5)

Recommendations:

1. Provide a multichannel aircraft radio, with pilot and passenger access to any Forest Service or cooperating agency high band FM channel of his choosing (150-174 MHz), for air attack control communications between aircraft. The radio must be integrated into the aircraft power and communications system. It must have the capacity to use a long range air net repeater communications system. All aircraft used on large fires (estimated number, 223) must have provisions for seasonal installation of this radio. (See Recommendation 15, Vol. 1, page 31.)

2. Fireline to air coordination communications must be provided simultaneously with air to air communications. A six-channel aircraft radio incorporating the three repeater associated single-frequency command channels and the three tactical channels should be provided for this purpose. All aircraft (except air tankers) used on large fires (estimated number, 147) must have provisions for seasonal installation of these radios.

3. Cache, in a National Radio Cache System, multichannel and six-channel aircraft radios, for installation in non-contract aircraft and helicopters (estimated number, 45).

4. A radio channel that can be accessed with VHF-AM multicom radios, normally installed in public and private aircraft, should be requested for use as a universal air emergency channel over large fires. (See Recommendation 15, Vol. 1, page 31.)

Figure 4, page 25, shows, schematically, the recommended air attack radio system; Figure 5, page 26, provides an operational illustration of the proposed system.

LONG RANGE AIR NET COMMUNICATIONS SYSTEM

Objective: To provide a long range support and dispatch communications channel from the air dispatcher, air base, and slurry base to aircraft enroute to and from large fires (Requirement No. 8).

Recommendations:

1. The present air net ground facilities should be retained and dedicated to serve the above objective. (See Recommendation 15, Vol. 1, page 31.)
2. Identify high fire occurrence areas within the service area of air bases and slurry bases and expand the ground support to air communications facilities to provide coverage to aircraft over these areas.
3. This network should serve as a national "standby" air channel, to be monitored by all aircraft when not engaged in air attack.

In general, these communications facilities already exist; but further expansion may be necessary.

SERVICE COMMUNICATION SYSTEM

Objective: Interference-free and reliable communications between fire camp and headquarters support facilities, for the primary use of command, supply and finance functions (Requirement No. 9).

Recommendations:

1. Telephone service should be utilized at the fire camps whenever it can be obtained at a reasonable cost. (A radio service net from a radio cache is estimated to cost between $500-$1000 per fire use and an additional $500-$1000 per year for amortization.)

2. Long range repeater type radio service networks should be provided in the National Radio Cache System for use when telephone service is not available at a reasonable cost (estimated 9 networks of 2 sets each with repeater.)

3. Slow speed facsimile equipment capable of operating over either a switched network telephone line or an FM radio channel, should be provided at the fire camp from the National Radio Cache System (estimated 9 sets of 2 units each).

4. When more than one large fire or multiple zoned fire is being supported from a command, supply, and finance headquarters, hunting system telephone call routing should be installed at the headquarters end.

5. Whenever possible the radio service nets should be "patched" into the commercial telephone system. Telephone patches should be provided in the National Radio Cache System for this purpose.
(See Recommendation 15, Vol, 1, page 31.)

INTRACAMP COMMUNICATION SYSTEM

Objective: Communications for key people within the fire camp (Requirement No. 10).

Recommendations:

1. Low cost, hand held, short range radios should be provided in the National Radio Cache System for intracamp communications (estimated 180 units).

2. A public address system should be provided for use at the main fire camp (estimated 15 systems). (See Recommendation 15, Vol. 1, page 31.)

COMMUNICATIONS MANAGEMENT

Objective: Smooth functioning of planning, procurement, installation and operation of communications on fires (Requirements No. 11 and 14).

Recommendations:

1. A GHQ communications officer should be designated when multiple large fires are handled from a central location (GHQ).

2. In all cases, a fire communications officer should be assigned to a large fire. (The technical supervision should be by the GHQ communications officer if a GHQ organization is required.)

3. A communications installation and maintenance technician should be assigned to each fire camp under the supervision of the fire communications officer.

4. A radio operator should be assigned to each fire camp under the supervision of the fire communications officer.

5. A communications equipment supply clerk should be assigned to GHQ supply to assist in obtaining communication equipment supplies. (This should be an electronics technician familiar with the jargon and sources of communications equipment supply).

6. An air communications officer should be assigned to work at the airbase under the technical supervision of the GHQ Communications Officer.

7. Job descriptions, training plans, and performance evaluation criteria should be developed and used.

   (See Recommendation 17, Vol. 1, page 35.)

Figure 6, page 27, illustrates, operationally, the total large fire communications system.

SOUTHERN CALIFORNIA INITIAL ATTACK COMMUNICATIONS RECOMMENDATIONS

Objectives: Provide means of fire line communications between forest and cooperator overhead and between forest overhead and ground tankers dispatched from adjoining forests before the arrival of National Radio Fire Cache equipment.

Recommendations:

1. Provide Forest Service overhead with hand-held HT 200's freed for use by implementation of the new National Radio Cache. (Required 90 units.)

2. Provide Forest Service owned Class 1 and 2 tankers on four Southern California forests with PT-300's and PT-400's freed for use by implementation of the new National Radio Cache. (Required 120 units.)

3. Provide Cooperator overhead with hand-held HT-200's or PT-300's freed for use by implementation of the new NRC. (Required 200 units.)

4. Provide forest dispatchers with AC utility sets. (Required 4 units.) Install to provide as much coverage as technically and economically feasible in the following order of priorities:

   a. Roads commonly travelled by off-forest tankers enroute to a fire on forest protected land.

   b. Roads commonly travelled by cooperator overhead enroute to a fire where joint attack is made.

   c. "Front range" forest protected land.

5. Provide two selected initial attack frequencies for repeater operation of the above network. (See Recommendation 16, Vol. 1, page 34.)

Figure 2. Recommended large fire ground attack radio system (including service and intra-camp networks)
Schematic representation with five channel radios.

Legend

C_{r1}, C_1, C_{r2}, C_2, C_{r3}, C_3	Command repeater and associated single-frequency channels*	T_1, T_2, T_3	Tactical single-frequency channels	S_{r1}, S_{r2}, S_{r3}	Service repeater channels	I_1, I_2	Intra-camp single-frequency channels

*Associated with any repeater pair of frequencies is a single-frequency channel that can be used without operating the repeater or without additional frequencies.

Fire Line Radio

Fire A: C_{r1} | C_1 | T_1 | T_2 | T_3
Fire B: C_{r2} | C_2 | T_1 | T_2 | T_3
Fire C: C_{r3} | C_3 | T_1 | T_2 | T_3

Command Assign.
(command module)
Fire Boss
Line Boss
General Scout
Helicopter Boss
Safety Officer
Misc. (3)

Tactical Assign.
(tactical module)
Division Boss
Sector Boss (3)
Crew Boss (9)
Helispot
Line Scout
Shift Change (5)
Misc. (2)

Fire Camp Radios

GHQ

Fire A: C_{r1} | C_1 | T_1 | T_2 | T_3 | S_{r1}
Fire B: C_{r2} | C_2 | T_1 | T_2 | T_3 | S_{r2}
Fire C: C_{r3} | C_3 | T_1 | T_2 | T_3 | S_{r3}

Remote Control

Remote Control

Function Assign.
Command
Service
Finance
Heliport

All Fires: I_1 | I_2

Assign.
Service Chief
Supply Officer
Comm. Officer
Trans. Officer
Others, as assigned

Spike Camp Radio

Fire A: C_{r1} | C_1 | T_1 | T_2 | T_3
Fire B: C_{r2} | C_2 | T_1 | T_2 | T_3
Fire C: C_{r3} | C_3 | T_1 | T_2 | T_3

Remote Control

Figure 3. Large fire ground attack radio system (including intra-camp and service).

Legend

Command Net ———
Tactical Net •—•—
Intra-Camp xxxxxxxx
Service Net • • • • • •

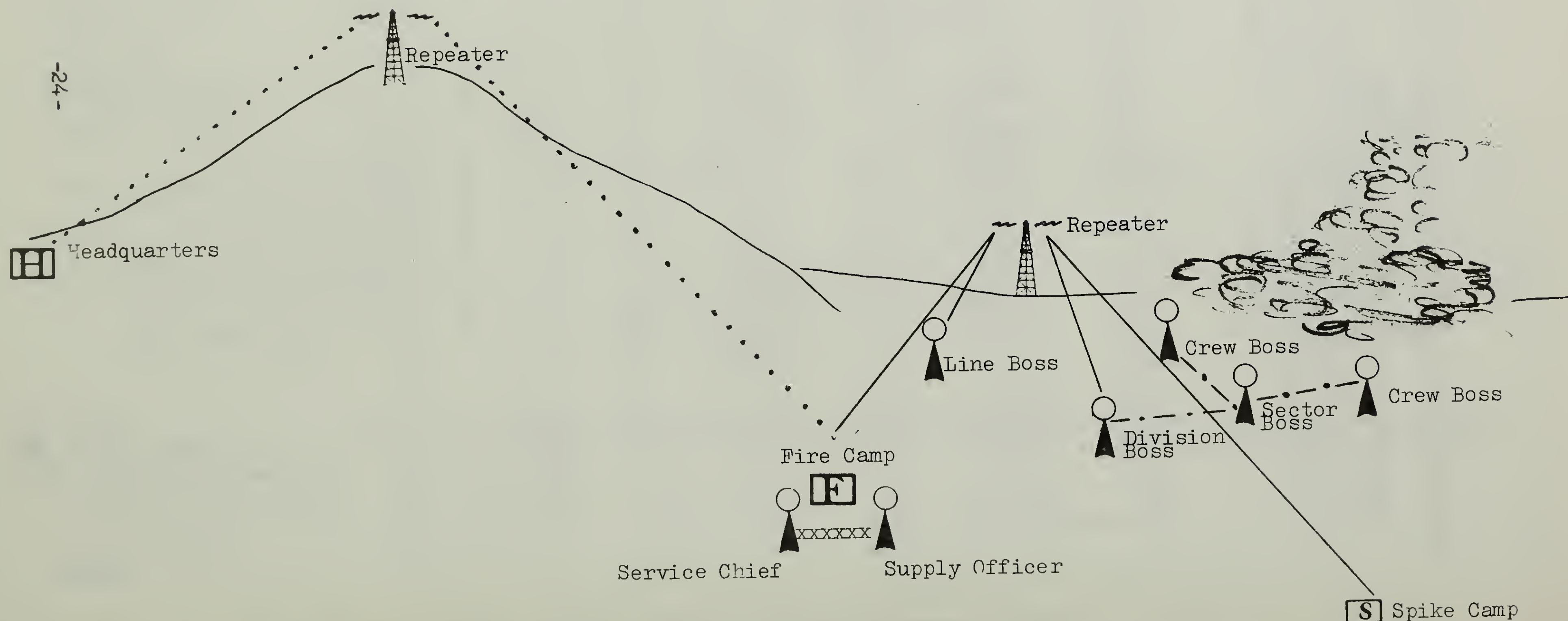


Figure 4. Recommended large fire aircraft radio communication system (includes provisions for line coordination).

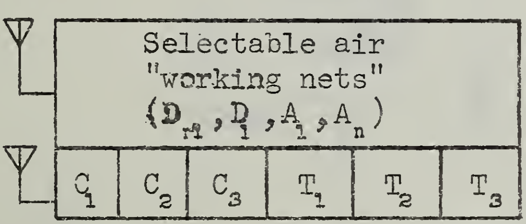
Legend

A_1, A_n — Air to air channels. Channel A_1 assigned permanently. Other channels (A_n) assigned temporarily from available Forest Service frequencies as needed.

D_{r1}, D_1 — Long range air net repeater and associated* single-frequency channel.

C_1, C_2, C_3 — Command associated* single-frequency channels.

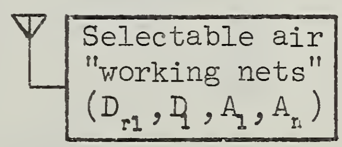
T_1, T_2, T_3 — Tactical single-frequency channels.



Aircraft Assignments:

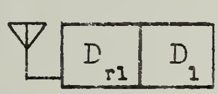
Air Attack Boss, Air Tanker Boss, Air Scout — Ground attack coordination over C_1, C_2, or C_3.

Helicopter-Tactical network coordination over T_1, T_2, or T_3.



Aircraft Assignments:

Air Tankers



Assignments:

Air Base
Slurry Base
Air Dispatcher

* Associated with any repeater pair of frequencies is a single-frequency channel that can be used without operating the repeater or without additional frequencies.

Figure 5. Large fire air attack radio system (including long range air net).

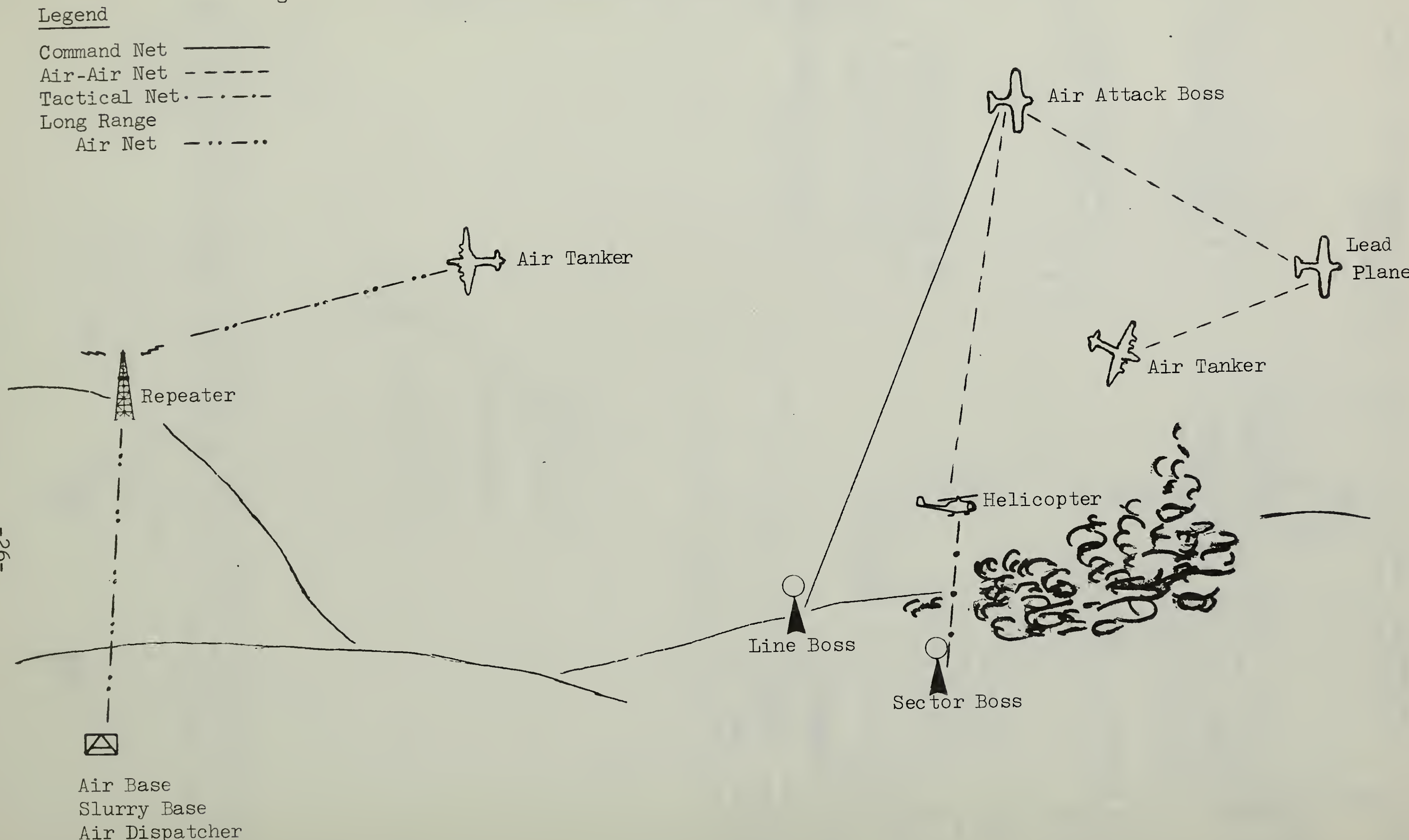
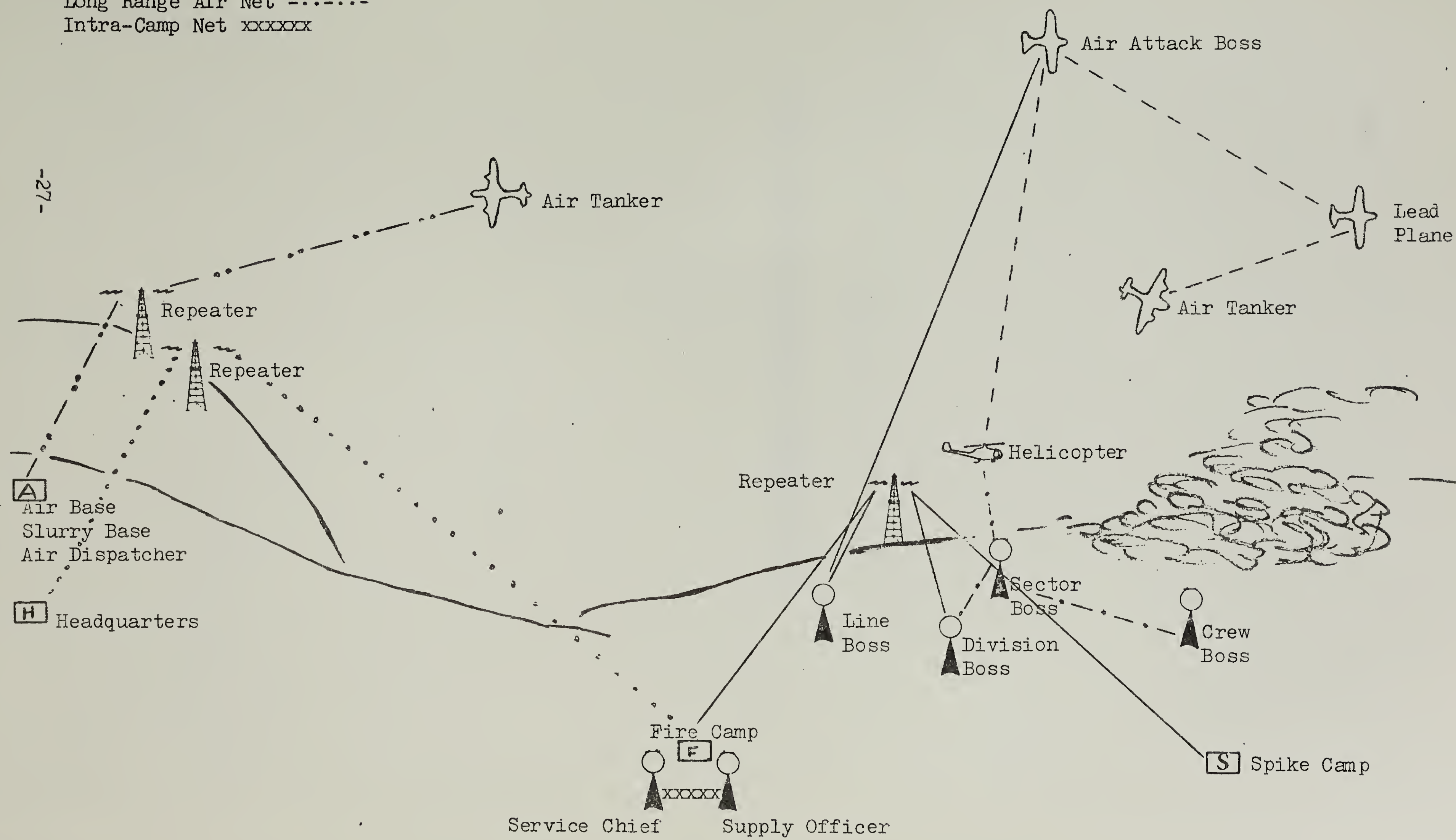


Figure 6. Complete large fire radio system.

Legend
Command Net ————
Tactical Net -·-·-·-
Air-Air Net -------
Service Net · · · · ·
Long Range Air Net -·····-
Intra-Camp Net xxxxxx



PART II

CACHE DESIGN AND SYSTEM IMPLEMENTATION

A. NATIONAL RADIO CACHE DESIGN RECOMMENDATIONS

Objective: A depository of radio and allied equipment necessary for fifteen fully manned simultaneous large fires (15 command modules and 46 tactical modules) with equipment located in such a way that sufficient modules will be available wherever a large fire occurs, ready for installation, within eight hours of notification (Requirements No. 12 and 13). The cache provides sufficient equipment to accommodate approximately 90% of the maximum demand experienced in the last 10 years.

Recommendations

The National Radio Cache should be composed of:

1. Fifteen command modules, each consisting of the following items:

   - Repeater (1)
   - 9-channel Base Radio (1)
   - Central Control Console (1)
   - 9-channel Personal Portables (8)
   - Public Address System (1)
   - Remote Control (1)
   - Extended Controls (3)
   - 1/4 Mile Spools of Single Pair Telephone Cable (4)
   - 2-channel Low Cost Personal Portables (12)
   - All Associated Accessories and Hardware

The Central Control Console provides common control of both the command and service networks. It also will allow switching of control to extended controls located at plans, service, and the main heliport. The configuration will provide for installation of slow speed facsimile and telephone patches. These can be used either on the command or service networks. In addition, the console will provide for control of the public address system. The Central Control Console should be designed to help organize, facilitate and improve system operation. All radios must be capable of being operated independently of the Central Control Console.

The 8 command personal portables are for top overhead line personnel (fire boss, line boss, general scout, heliport or helicopter boss, safety officer and 3 for miscellaneous assignment).

2. Forty-six tactical modules consisting of 21 radios each, assigned as follows:

   - Division Boss (1)
   - Sector Boss (3)
   - Crew Boss (9)
   - Helispot (1)
   - Line Scout (1)
   - Unassigned Special Functions (2)
   - Shift Change Allowance (4)

The Division boss radio is cached as part of the tactical module rather than the command module for shipping purposes. (NOTE 1.: If 5-channel rather than 9-channel radios are used, the total number of modules must be divided into three groups, one for each repeater frequency.)

The following modules (3, 4, 5 and 6) are not always required on large fires and are therefore packaged separately.

3. Fifteen spike camp modules, each consisting of the following items:

   - 9-channel Base Radio (1)
   - Remote Control (1)
   - 1/4 Mile Spools of Single Pair Telephone Cable (4)

(NOTE 2.: There are alternative ways of providing communications to spike camps other than over the command net, as implied above. Large fires with several spike camps and many command positions with the total number of active stations exceeding 20, should consider transmitting spike camps to main camp radio traffic on a separate service network or perhaps an unused command network.

Whatever means is chosen for spike camps to main camp communications, a spike camp module is still required to enable the spike camp to communicate with tactical line personnel and aircraft.)

4. Nine service modules (3 on each of three service repeater channels) each consisting of the following items:

   - UHF Repeater (1)
   - UHF Base Stations (2)
   - Remote Controls (2)
   - Extended Controls (3)
   - Telephone Patch (1)
   - 1/4 Mile Spools of Single Pair Telephone Cable (8)

The extended controls provide access to the fire camp radio for the fire camp functions of command, service and finance.

5. Nine slow speed facsimile modules. These modules will consist of two facsimile units capable of being operated over either a switched network telephone line or the service radio networks. Each base station and remote control should have the capability to use slow speed facsimile. The general headquarters terminal must be capable of being patched into a commercial telephone system.

6. Aircraft and helicopter modules must be cached if the practice of using non-contract aircraft on large fires is continued. (Based on available information of need, 45 modules are included in the cache for cost estimation purposes.)

B. LARGE FIRE COMMUNICATIONS SYSTEM IMPLEMENTATION RECOMMENDATIONS

Recommendations

1. Location of the National Fire Cache. The fire cache should be centrally located for the purposes of efficient management, storage, and maintenance. A flexible cache pre-positioning plan should be developed. Fire Control and Communications and Electronics should develop training plans for communications officers in the use of the Cache.

2. Equipment Purchases Requirements. The numbers of units required for the air system (Table 3, page 35) are based on oral and written estimates by Regional Fire Control Officers (appendix, Table A3.) Table 4, page 36 summarizes purchases necessary for the proposed Large Fire Communications System and equipment on hand.

3a. Equipment Purchase and Installation Costs. The estimated cost of implementation of the air attack system and National Radio Cache System are as follows (including a 30% management assessment on each item):

- Multichannel radios @ $4000 (268)	$1,531,429
- 6-Channel radios @ $2000 (192)	548,571
- Installation @ $1000 (223)	318,571
- 9-Channel portable @ $650 (871)	808,786
- 9-Channel base @ $1000 (30)	42,857
- Repeater and hardware @ $1500 (15)	32,143
- Remote control @$300 (48)	20,571
- Extended control @ $150 (72)	15,429
- Central control console @ $1000 (15)	21,429
- Short-range portable @ $60 (180)	15,429
- Public address system @ $300 (15)	6,429
- UHF service base @ $2000 (18)	51,429
- UHF service repeater and hardware @ $3000 (9)	38,571
- Telephone patches @ $200 (9)	2,571

- Facsimile terminal rental 3 months per year @ $120 (18)	$ 3,086
- Telephone wire 1/4 mi. spools @ $5 (192)	1,371
- Frequency conversions of present equipment	35,714
- Packaging, marking, and miscellaneous	28,571
Total	$3,522,957

3b. The estimated costs of the installation and conversion of present fire radio cache equipment (regional and central caches) for use on four Southern California forests are as follows:

*210 installations @ $200	$ 60,000
*210 frequency changes @$50	15,000
4 installations of AC utility sets @ $1500	8,571
8 low power mobile repeaters -- complete @ $3500	40,000
Total	$123,571

3c. The sum of items 3a and 3b represents the estimated initial investment in the recommended Large Fire Communication System. This sum is:

Total estimated initial investment: $3,646,528

* Above estimate assumes cooperators will bear the expense of necessary installations and frequency changes on assigned equipment.

(See Recommendation 18, Vol. 1, page 36.)

4. Frequencies.

Required Frequencies for National Fire Cache System:

1. three command repeater pairs
2. three tactical frequencies
3. three UHF service repeater pairs

within crystal switching range

Required Frequencies for Air and Ground Support System:

1. one permanently assigned air to air frequency
2. one long range air repeater pair
3. the provision to quickly select up to five or more free Forest Service VHF-FM high band channels for any particular fire
4. one FAA controlled VHF-AM air safety frequency

5. Financing.

In the case of air attack and the National Fire Cache System, a one-time appropriation should be requested for full implementation.

The present air net system will serve the requirements of the air to ground support network. A one-time appropriation will be required to change the air net system frequencies in Region 1 to comply with the long range air net recommendations.

Subsequent improvements, rental charges and replacements should be financed within the Forest Service program.

Table 3. Aircraft radio purchase requirements.

	Multichannel Aircraft Radios	6-Channel (Crystal Controlled) Aircraft Radios
Air Tankers	76	--
Lead Planes	24	24
Cargo and Jump Planes	26	26
Observer Planes	10	10
Contract Helicopters	81	81
Other FS-owned Planes	6	6
Totals	223	147

Table 4. Equipment purchase requirements for implementation of the large fire communications system.

Equipment Type Requirements	Cache Module Type						Sub-Totals			Total Purchase Reqmnts.
	Com. Mod.	Tac. Mod.	Serv. Mod.	S.C. Mod.	Facs. Mod	Air* Mod.	Cache Req.	Air Req	On Hand	
Multichannel Aircraft Radio						45	45	223		268
6-Channel Crystal Cont. Aircraft Radio						45	45	147		192
9-Channel Portable	120	966					1086		** 215	871
9-Channel Base	15			15			30			30
Repeater	15						15			15
Remote Control	15		18	15			48			48
Extended Control	45		27				72			72
Central Control Console	15						15			15
Short-Range Portable	180						180			180
Public Address System	15						15			15
UHF Base			18				18			18
UHF Repeater			9				9			9
Telephone Patch			9				9			9
Facsimile Terminals					18		18			18
Spools of Telephone Wire	60		72	60			192			192

* Non-contract aircraft modules

** 5-channel portable radios from present fire caches and other sources

PART III

PRESENT AND PROPOSED SYSTEM COMPARISON

PRESENT AND PROPOSED SYSTEM COMPARISON

Subsystems will be compared separately in the order followed in Part I , system design.

Ground Attack Communications

The present method of providing ground attack communications has not met the requirements as previously summarized in Part I. Most Regions have their own radio fire caches. These caches are often not compatible in frequencies, channel arrangement, and other operational aspects. The lack of compatible equipment on a nationwide basis makes it difficult and often impossible to use equipment from different caches together. Some regions have relatively modern cache radios that are easy to carry and operate; others have old castoff equipment that is heavy to carry and difficult to operate. The only exception is the Boise Interagency Fire Center which now offers a modern, compatible radio cache of significant size. This is the first step towards meeting the requirements.

The following existing operational and efficiency problems will be eliminated or reduced by the proposed system:

1. Ground crew safety -- In most cases crew bosses and, in some cases, sector bosses, are not assigned radios (IR crews excepted). When they do have radios they are incapable of communicating with air operations. The proposed system eliminates this safety problem. Crew bosses can talk to support helicopters on the tactical network and, in addition, have emergency access to the command repeater network.

2. Crew efficiency -- In some cases, crews cannot be utilized to full efficiency because they have no quick, direct communications with their sector boss. The proposed system provides radio links between sector boss and crew boss over the tactical network.

3. Congestion and interference -- The proposed system separates command and tactical communications and insures channel overloads will not occur because of too many radios on the fire network.

4. Need for key command and sector personnel to carry two radios in order to coordinate with air operations -- The proposed system eliminates this need. All aircraft have ground attack communications channels installed.

Based on questionnaire responses, the proposed system is conservatively expected to increase line productivity by 14% (average minimum estimate) and result in probable resource savings (appendix Table A4, page A6). The system will also contribute significantly to fireline safety with possible benefits from reduced fireline fatalities.

Air Attack Communications

The present air net repeater system does not meet requirements as summarized in Part I. Air attack has simply outgrown the capabilities of the present system. The present system attempts to provide all the aspects of air attack communications: 1) dispatch and air support communications, 2) air attack control communications and 3) air - ground attack coordination communications. This results in breaches in air safety, confused and inefficient air attack, dependence on non-proprietary FAA frequencies, duplication of radios for line people, limited line coordination, and no emergency contact between line workers and aircraft. Air operations, because of the outmoded communications system, have been restrained from operating at full capabilities. The proposed system offers solutions to all these problems; furthermore, the flexibility of its design will assure that the system will not become obsolete in the near future.

To the question, "Why do we not continue to use FAA frequencies that have relieved some of the pressure on air communications in the last two years? This would make it unnecessary to purchase and install our own system", the answers are as follows:

1. The frequencies are not proprietary and we therefore have no ultimate control. They are under the allocation and use control of the Federal Aviation Administration (FAA).

2. The emergency use arrangements are temporary and could be withdrawn at any time the FAA decides that they need the frequencies.

3. Unused FAA frequencies are increasingly difficult to find especially in metropolitan areas, such as Southern California.

4. We can expect the FAA frequencies to become unavailable as commercial and private aviation expands.

5. FAA frequencies cannot be used (legally) for initial attack or non-fire situations either in air operations or ground coordination.

6. United States Frequency Management Authorities (IRAC and FCC) did not intend these frequencies to be used for fire suppression work. When temporarily assigned, they are for emergency use.

Large fire questionnaire respondents have indicated expected gains in air attack and coordination efficiencies of about 23% (average minimum estimate) if adequate air attack communications were available (appendix Table A4, page A6). There are also possible resource savings in better coordination in initial fire attack.

Long Range Air Net Communications

The present regional repeater air net system does not meet separate channel requirements. Inadvertent, and oftentimes emergency use of the present repeater air net system by dispatchers and other ground stations have caused carefully staged retardant drops to be aborted. The resultant confusion in air operations and interference experienced in the system will be eliminated by adoption of the proposed system. The increased efficiency of a separate air dispatcher and support system will be a large contributor to the overall gain in efficiency expected with the proposed large fire system.

Service Communications

The present service communications system uses several techniques. If telephone service is available it is used, but often not to the best advantage. Options in telephone service are generally not considered. If telephone service is unavailable, most often forest radio nets are pressed into service. This hinders the forest in carying on its other duties of fire detection, initial attack and other emergency responses. Sometimes the forest net does not provide adequate coverage to the fire camp site. Some regions have taken leadership in the service communications area, but the radio systems are not coordinated among regions and often frequency incompatibility occurs with the use of equipment from different regions. The ability to properly place and follow-up on supply orders, the ability to speedily and effectively service a large fire and the effectiveness of other fire activities on the forest will be significantly increased by the proposed service communications system. Increased efficiency, because of adequate service communications, will be a large contributor to the overall gain in efficiency expected with the proposed large fire system.

Intracamp Communications

The present intracamp communications sytem uses whatever is available from bull horns to field telephones. It does not meet requirements as summarized in Part I. The inability to contact key people in the fire camp when necessary will be virtually eliminated with the proposed system. Disruption of camp activities and of the rest of weary fire fighters by blasting bull horns and public address systems will be drastically reduced. Ability to contact anyone in camp for an emergency will be retained and enhanced.

PART IV

DETAILED ANALYSES

A. DESCRIPTION AND COMPARISON OF LARGE FIRE COMMUNICATIONS SYSTEMS ALTERNATIVES

Reasonable alternatives will be proposed and compared for each subsystem of the large fire communication system.

GROUND ATTACK COMMUNICATIONS SYSTEM ALTERNATIVES

The requirements of this communications subsystem are detailed in requirements 1, 2, 3, 4, 5, and 13, summarized on pages 10 and 12.

The referenced requirements make certain demands on the Ground Attack Communications System.

1. The command network must be a repeater network because direct communications are required among people and places located around the entire fire perimeter.

2. The tactical network should have non-repeater channels contained in a single radio. Intra-division communications requirements are short range and all three channels may be used on a single fire.

3. All personnel assigned radios must have at least one common channel to provide an emergency communications link.

There are three alternatives for meeting the requirements and equipment demands. These alternatives were selected because they show the three basic approaches, 1) identical radios and networks, 2) single network with different radios or 3) identical radios in different networks. The alternatives are illustrated in Fig. 7, page 53 and are described below:

Alternative 1 - - Universal 9 - Channel Personal Portable Radio

This radio would contain all three command repeater pairs (a pair consists of a repeater channel and its associated single frequency channel) and the 3 single-frequency tactical channels. One of the repeater pair command channels would be available for assignment on a fire. In an emergency all line personnel with radios would have access to the command repeater network. Equipment would be standard and completely interchangeable.

Alternative 2 - - Different Command and Tactical Network Radios

There would be two kinds of radios, a command and a tactical radio. The command radio would be a four-channel radio that contained three repeater channels (no associated single-frequency channels) and a universal "calling" channel that meets the safety requirement of contact among air support and all ground personnel. The tactical radio would also be a four-channel radio with the three tactical channels and the universal "calling" channel. All command radios and all tactical radios would be standardized, but not interchangeable.

Alternative 3 - - Different Networks with Identical Command and Tactical Radios

There would be three different networks, differentiated by the command repeater pair channel used in the network. Each network would have identical five channel radios with one command repeater channel, its associated single-frequency channel, and all three tactical channels (all radios would contain the three tactical channels). A single fire or fire zone would have one of the networks. Other fires within interference range of the command repeater channel would use one of the other two networks. Because the radios on any given fire would be identical, all air support and line personnel would be in emergency contact. Each of the three networks would be standard. Within a network radios would be interchangeable. Radios would not be interchangeable between networks.

Comparison of Alternatives

The three alternatives that meet the requirements are compared in Table 5, page 54, on the basis of their relative advantages and costs. The important advantages to fire attack and fire management which are also significantly different for the alternatives are:

1. System management simplicity
2. User simplicity
3. Flexibility of use and expansion
4. System interface requirements
5. Degree of system standardization
6. Degree of emergency safety communications provided

Alternative 1 offers the greatest management simplicity because all radios are identical and cannot be shipped in the wrong configurations or misassigned.

User simplicity is best for alternative 2 because only the "working network" channels are available to individuals assigned radios. They have no opportunity to switch to the wrong network. The other alternatives have both command and tactical network channels available and, conceivably, an individual could become confused and select the wrong network channel.

Flexibility of use and expansion is best for alternative 1 because all channels are available. Alternative 2 is considered the worst. Although it has all tactical channels and all command repeater channels, they are contained in separate radios. Moreover, it does not have the repeater associated single-frequency channels; consequently, all command communications must be carried out using the repeater. Alternative 3 has good flexibility with all tactical channels available, along with one command repeater channel and its associated single-frequency channel.

The command and tactical network interface problems are worst with alternative 2 since key personnel such as division bosses and the helicopter boss must carry both command and tactical radios. No such problem exists with the other alternatives; no one must carry more than one radio.

System standardization is best with alternative 1 because all radios are the same. Alternatives 2 and 3 are about the same, with two different radios required for alternative 2 and three different networks for alternative 3.

Emergency communications provided are the same for alternative 1 and 3. All line personnel have emergency access to the command repeater network. Alternative 2 only marginally meets emergency requirements because:

1. Line coverage is limited by the single-frequency emergency channel.

2. The emergency channel is only available when selected by both users. (No simultaneous monitoring of the "working" channel and emergency channel is available at a reasonable cost for hand-held radios.)

These problems would necessitate that certain people be designated to monitor the emergency channel continuously.

Alternative 2 offers considerably fewer advantages than alternative 3 and would cost more because division bosses and others would require duplicate radios. If alternative 3 is adopted it is possible to have some radios remain in the cache unusable because a residue of 10 to 15 radios may be left in each network that would not serve an additional fire properly. No such problem exists in alternative 1 because all radios are interchangeable. For these reasons we recommend alternative 1 if the cost of nine-channel portable radios is not excessive.

AIR ATTACK COMMUNICATIONS SYSTEM ALTERNATIVES

Air attack communications are defined as air-to-air control communications and air to ground attack coordination communications. Long range air communications will be discussed separately. The requirements for air attack communications are presented in items 1, 2, 3, and 5, page 10, summary of requirements. The present national air net system cannot meet the identified requirements.

Two equipment types and two channel monitoring techniques, resulting in four system alternatives, are in various stages of development. The two types of equipment are:

1. Multichannel radio - - uses electronic techniques to create all FM channels in the high band (150-174MHz). The channels would be selectable at the pilot's discretion.

2. Crystal controlled radio - - uses crystal control techniques to determine channel frequency. Only a fixed number of predetermined channels could be selected by the pilot.

The four alternatives that have a reasonable chance of development are:

Alternative 1. Multichannel aircraft radio with simultaneous two channel monitoring. The air control and the ground attack coordination channels would be selected and simultaneously monitored internally. When a signal is received on either channel the receiver would lock on that signal until the message was over, then revert back to simultaneous monitoring. Transmitter frequencies would be independently selectable by the operator. This type of radio would also be used for long range air communications.

Alternative 2. Multichannel aircraft radio and an additional six-channel crystal controlled radio (recommended alternative). On large fires, the multichannel aircraft radio would be used for air to air control. The crystal controlled radio with the six ground attack channels installed would be used for ground attack coordination. The multichannel aircraft radio would also be used for long range air communications.

Alternative 3. Crystal controlled, twelve-channel radio with simultaneous two channel monitoring. The air control and the ground attack coordination channels would be selected and monitored simultaneously. The radio would operate exactly as in the first alternative. This radio would require four air control, six ground attack coordination, and the long range air net repeater channel, a total of twelve channels.

Alternative 4. Two crystal controlled, six-channel radios. One radio would be reserved for air to air control, and the other for ground attack coordination. The air to air control radio would have six channels (four air control channels, and the long range air net repeater channel).

Figure 8, page 55 shows schematically the four alternatives.

Comparison of Alternatives

The four alternatives are compared in Table 6, page 56, on the basis of their relative advantages and costs. The significant differences between the alternatives important to fire attack and fire management are:

1. Adaptability of the system to initial attack or non-large fire situations.
2. Adaptability of the system to future unidentified requirements or unplanned for overloads.
3. Suitability of the system to non-fire communications needs.
4. Coordination possibilities with other fire fighting agencies.
5. Ease and simplicity of simultaneous monitoring.

Due to the multichannel capability, alternatives 1 and 2 are superior to the others for initial attack, small fire situations and non-fire communications. With the multichannel type radio installed, the aircraft can dial up the Forest frequency or whatever frequency is being used on the ground. The other alternatives require the ground forces to carry a special ground to air radio.

Alternative 1 is best from the viewpoint of future expansion of the large fire communications system. The multichannel radio is not limited to the identified requirements of four air control channels or six ground attack coordination channels. During temporary overloads on the air control channels, additional channels, beyond the identified minimum of four, can be temporarily assigned from Forest Service frequencies not used in the area of the fire. Alternative 2 offers expansion opportunities for the air control system, but not for air to ground attack coordination. Alternatives 3 and 4 are limited to the number of channels and frequencies selected with the initial installation. Growth and expansion will be very expensive.

Coordination with other fire fighting agencies can be accomplished quite well with alternative 1 or 2. Most of these agencies use high-band-FM channels for their communications. With proper agreements between agencies, the multichannel radio permits selection of any of these frequencies for use. Alternatives 3 and 4 would require that equipment exchanges and installations be made before communications could be established.

The best monitoring ease is provided by alternatives 1 and 3. Simultaneous monitoring is accomplished within the radio equipment and only front panel radio controls are required. There is the possibility, however, of important or emergency messages lost on one channel when the receiver was locked on another channel. Alternatives 2 and 4, although

just as effective as the other alternatives, require special mixing boxes and additional controls external to the two radios.

Alternatives 3 and 4 are estimated to cost approximately $2000 less than alternatives 1 and 2, but they offer none of the advantages and flexibility of 1 and 2. We feel the advantages outweight the costs. There are added major savings to the Forest Service if either alternative 1 or 2 is selected. Forest ground crews through the Forest Service will no longer require additional radios for air coordination of day-to-day fire detection or initial attack. Operationally, alternative 1 is the ideal alternative and would probably cost less overall. However, it is unlikely that this radio will be available in the near future. In addition, the lack of simultaneous receive capability could be a serious defect in busy or hazardous situations. For the above reasons, we recommend alternative 2.

LONG RANGE AIR COMMUNICATIONS

Long range air communications are defined as communications between aircraft and air ground dispatch or support facilities. The requirements for this communications network are noted in requirement No. 8, page 11.

In summary, the requirement is for long-range communications over a channel separate from other air communications. The present air net system, dedicated to this purpose, is the only acceptable alternative. The system would require that all regional air dispatch and support communication systems utilize the same frequencies.

A complete new system would not serve the requirements of air dispatch and support activities any better than the present air net system dedicated to this purpose. The costs of a new system would inevitably exceed the costs of the required modifications to retain the present system. (It should be noted that the requirement can be met by adding one simultaneous monitoring channel to the multichannel aircraft radio.) For these reasons, we recommend dedicating the present airnet system to long range air communications.

SERVICE COMMUNICATIONS SYSTEM ALTERNATIVES

Service communications are defined as communications between the main fire camp and headquarters command, supply, and finance functions. The requirements of this communications subsystem are specified in requirement No. 9 of the summary of requirements, page 11. The requirement is for a separate long range communications channel with hard copy transmission capability.

There are basically two alternatives for the communication link as follows:

Alternative 1. Telephone (including radio telephone service).

Alternative 2. Radio network.

The telephone alternative has various types of line and call routing available. The major line options are:

a. Multipoint private line - - provides service only between two or more designated points without access to or from the normal dial system. It is often call a "hot line" or "intercom" line.

b. Switched network line - - normal dial access single party or multiparty line.
c. Radio telephone - - a Bell System supplied radio extension of normal telephone service. Its operation utilizes the switched network system.

The major call routing options available are:

a. Rotary (hunting) system - - This call routing system allows incoming calls to hunt for a free line among all those lines assigned to the subscriber. There is only one telephone number for all the lines.
b. Normal system - - This system assigns each subscriber line a different number. If a line is busy it must be redialed by number. The call cannot be rotated to a free subscriber line and held until the desired party is free.

The radio alternative has the following major options available:

1. Single Sideband - - Single sideband is amplitude modulated, usually High Frequency (HF), at about 3 to 30 MHz. Communications can be established over extremely long distances without intermediate repeaters. Accessories are large and bulky. Several frequencies are required to insure radio path reliability. The required frequencies are generally available.

2. Microwave - - This service has very short range, line-of-sight propagation characteristics and very high channel capacity. Accessories are small and compact. Frequencies are generally available.

3. Frequency Modulated, Lowband - - This service has close to line-of-sight propagation characteristics. It is subject to unpredictable long range interference. Accessories are large and bulky. Frequencies are generally available.

4. Frequency Modulated, Highband - - This service has line-of-sight propagation characteristic. It is not subject to long range interference. Accessories are small and compact. Frequencies are at a premium and approach unavailability.

5. Frequency Modulated, UHF - - This service has line-of-sight propagation characteristics. It is not subject to long range interference, but is subject to certain atmospheric disturbances. Accessories are small and compact. Frequencies are available and unused.

Comparison of Alternatives

Comparison of alternatives and options will be made on the basis of relative advantages and costs. The following advantages are important to fire attack and fire management, and are also significantly different for the alternatives being compared:

1. Ease and quickness of system installation.
2. Portability of the equipment

3. Reliability of the equipment
4. Flexibility for expansion of message capacity
5. Availability of the equipment
6. Simplicity of operation

Table 7, page 57, compares the telephone alternatives (and options) with the radio alternative. Radio options will be compared later, using technical as well as operational criteria.

The telephone alternative is the easiest to install. The telephone company has trained people to do installation; radios require trained Forest Service personnel for installation. Only instruments and a few hundred feet of line must be installed to have an operating telephone system. The radio alternative requires a full system installation.

Portability is poor with the telephone alternative unless the radio telephone option is used.

The telephone offers the most reliable service. Excepted is the radio telephone option, which is about the same as radio. When multipoint private lines fail they are hard to reroute. A switched network line offers the best in reliability because line failures can easily be switched out of the network. Failures in either radio telephone or radio are difficult to correct.

The message capacity of radio or multipoint private lines is good because the channel can be continuously monitored. In the case of switched network lines and radio telephone this is not possible because a busy line must be redialed. This problem is relieved, somewhat, by a rotary (hunting) system of call routing at the receiving end. Multiple lines could then be automatically polled for a free line. Radio telephone has an additional message capacity disadvantage stemming from many users sharing a maximum of eight channels.

The telephone alternative is not always available. This is its major disadvantage. Multipoint private lines are seldom available, switch network lines are available for about 50% of the large fires, and radio telephone is often not available because of radio system coverage limitations.

Simplicity of operation is most easily achieved by means of the multipoint private line and the switched network line. While most people know how to operate telephones, special knowledge and skill is required to operate either a radio telephone or radio.

It is clear from the above comparison and the costs shown in Table 7 that telephone service is the best alternative when it is available with reasonable construction costs ($1000 to $1,500).

Observed construction costs have ranged from $200 to $1000 per mile. A single large fire would need up to two switched network lines; the headquarters end would use their existing telephone system. In a multiple or zoned fire situation, problems of congestion and call routing are likely to exist at the headquarters and not at the individual fire camps.

Therefore, a rotary (hunting) system of call routing should be installed at the headquarters. Multipoint private lines can also be useful in multiple fire situations. Sometimes radio telephone is available when telephone line construction is too expensive. Definitive recommendations cannot be made; the specific situation must be considered.

If telephone service is unavailable or construction costs are found to be prohibitive, radio becomes the only alternative. Table 8, page 58, compares the major radio options. Microwave can be dismissed because of its prohibitive expense and because the large number of channels available with a microwave system are presently not required. Future requirements may demand reconsideration of the microwave option. Single-sideband and low band FM, although estimated to be the least expensive, are inferior to the other options in path reliability and would be more difficult to install. Of the two remaining options, UHF is somewhat easier and quicker to install than high band FM. UHF accessories are smaller, lighter, and more compact. UHF and high band FM have a similar range of operation. UHF has one significant technical advantage; frequencies in the high band are scarce and badly needed for other Forest Service uses while frequencies in UHF are available and as yet unused.

While a UHF-FM unit is more expensive, we feel the technical advantage, along with the operational advantages, outweigh the added expense. We recommend that any existing service networks be retained and that new UHF-FM units be purchased.

In summary, a telephone system is the best alternative when available with moderate construction costs. This situation should occur about 50% of the time. Radio service links should be stored in a National Radio Cache System to serve the other 50% of the fires. The best alternative for a specific situation should be based on the following considerations:

1. Specific situation requirements
2. Availability of services
3. Costs of service

INTRACAMP COMMUNICATIONS SYSTEM ALTERNATIVES

Intracamp communications are defined as communications between overhead or individuals within the main fire camp. The requirements of this communications subsystem are specified in requirement No. 10, page 11.

The communications requirement is short range and both ways. The people who require it are very mobile. Several methods of meeting this requirement have been suggested, from public address systems to citizen band radios. The three alternatives are as follows:

Alternative 1. Wire Intercom. Wire would be strung between each area or tent of importance, and intercom stations installed. Each station could talk to each other station and several conversations could be carried on simultaneously.

Alternative 2. Public Address System. A control point sends amplified messages over a loudspeaker system installed around the fire camp. A public address system, by itself, does not meet the requirements because communication is not possible both ways. However, it is the only alternative that can reach everyone in the fire camp.

Alternative 3. Low Cost, Short Range Radio. Hand-held radios on an independent frequency would be issued to people requiring communications around the fire camp.

Comparison of Alternatives

Only alternatives 1 and 3 which meet requirements will be compared in Table 9, page 59. (Alternative 2 will be discussed.) The following significant differences between the alternatives are important to fire attack and fire management:

a) Ease and quickness of system installation
b) Station portability
c) Sturdiness and reliability
d) The ability to communicate in emergencies with people not assigned equipment.

The radio alternative clearly is better for installation ease and portability. Wire intercom is in some ways more reliable and much sturdier. Radio does offer a subtle reliability advantage. When a radio fails, the system will continue to operate. This is not usually true with a wire intercom; wires can be torn out or broken and the whole system will fail. Three examples of this type of failure were observed by the study team during the 1970 fire season. With normal care by the user the radio should be sufficiently reliable. The costs shown in Table 9 are initial investment costs. Wire intercom and radio costs are about the same since quipment life is about the same. Therefore, we propose that low-cost, short-range radios become the standard intracamp communications tool.

Large fires are an emergency situation. Emergency communications to those normally without camp communications are occasionally required. For this reason we feel a public address system should also be supplied to fire camps in addition to standard intracamp communications. The initial cost is estimated to be about $250.

Figure 7. Ground attack communications system alternatives.

Legend

$*C_{R1}$, C_1, C_{R2}, C_2, C_{R3}, C_3 — Command 3 channel repeater system

T_1, T_2, T_3 — Tactical 3 channel system (single-frequency channels)

$*$ (R1 — Channel configured for repeater use; 1 — Associated single-frequency channel)

U_1 — Universal safety channel

<u>ALTERNATIVE 1</u> - Universal 9 channel Personal Portable Radio

C_{R1}	C_1	C_{R2}	C_2	C_{R3}	C_3	T_1	T_2	T_3

Command and Tactical

All ground personnel
Fire Camp
Spike Camps
Heliport
Helispots

<u>ALTERNATIVE 2</u> - Different Command & Tactical Network Radios

C_{R1}	C_{R2}	C_{R3}	U_1

Command

Fire Boss
Line Boss
Division Boss
Helicopter Boss
Fire Camp
Spike Camp
Heliport

T_1	T_2	T_3	U_1

Tactical

Division Boss
Sector Boss
Crew Boss
Helicopter Boss
Spike Camps
Heliport
Helispot

<u>ALTERNATIVE 3</u> - Different Networks with Identical Radios

C_{R1}	C_1	T_1	T_2	T_3	First Network
C_{R2}	C_2	T_1	T_2	T_3	Second Network
C_{R3}	C_3	T_1	T_2	T_3	Third Network

Command and Tactical

All ground personnel
Fire Camp
Spike Camps
Heliport
Helispots

Table 5. Comparison of ground attack communication system alternatives

	Rating of Alternatives		
	Alt. 1 Universal Radio 9-channel	Alt. 2 Different Network Radios	Alt. 3 Different Networks
System Management Simplicity	Best	Good	Good
User Simplicity	Good	Best	Good
Flexibility of Use and Expansion	Best	Worst	Good
System Interface Requirments	Good	Worst	Good
System Standardization	Best	Good	Good
Emergency Communications Provided	Good	Worst	Good
Estimated Cost per Unit		$625	$650

Figure 8. Air attack communications system alternatives

Legend

- *C_{R1}, C_1, C_{R2}, C_2, C_{R3}, C_3 } Command 3 channel repeater system
- *D_{R1}, D_1 } Long range air net 1 channel repeater system
- T_1, T_2, T_3 } Tactical 3 channel system (single-frequency channels)
- A_1, A_2, A_3, A_4 } Air to air control 4 channel system (single-freq. channels)
- $S_{n/sm}$ } Radio capable of all channels above and any one other channel on simultaneous receive
- S_n } Multichannel radio capable of all channels above

* (R1 - Channel configured for repeater use; 1 - Associated single-freq. channels)

ALTERNATIVE 1
Multi channel radio with simultaneous monitoring

$S_{n/sm}$

All Aircraft

ALTERNATIVE 2 -
Multi channel radio without simultaneous monitoring and a 6 channel crystal controlled radio for ground attack coordination (Recommended)

S_n					
C_1	C_2	C_3	T_1	T_2	T_3

Air Attack Boss
Lead Plane
Cargo Plane
Jump Plane
Helicopters

S_n

Air Tankers

ALTERNATIVE 3 - Crystal controlled, 12-channel radio with simultaneous monitoring

D_{R1}	D_1	A_1	A_2	A_3	A_4	C_1	C_2	C_3	T_1	T_2	T_3

All Aircraft

ALTERNATIVE 4 - Crystal controlled, 6-channel radio for ground support and air control operations and another 6-channel radio for ground attack coordination, neither radio with simultaneous monitoring.

D_{R1}	D_1	A_1	A_2	A_3	A_4
C_1	C_2	C_3	T_1	T_2	T_3

Air Attack Boss
Lead Plane
Cargo Plane
Jump Plane
Helicopters

D_{R1}	D_1	A_1	A_2	A_3	A_4

Air Tanker

Table 6. Comparison of air attack communications system alternatives.

Advantages	Alt. 1 Multi-Channel w/monitoring	Alt. 2 (Recommended) Multi-Channel w/ 6-Channel	Alt. 3 12-Channel w/monitoring	Alt. 4 Two 6-Channel
Initial Attack or Non-Large Fire	Good	Good	Poor	Poor
Future and Unplanned Requirements	Best	Good	Poor	Poor
Non-Fire Communications	Good	Good	Poor	Poor
Other Agency Coordination	Good	Good	Poor	Poor
Monitoring Ease	Good	Fair	Good	Fair
Estimated Cost 1/	$5000	$6000	$3000	$4000

1/ These costs are rough estimates, since none of these radios are actually developed. If final decisions are based on costs alone, more precise cost data based on specific proposals would have to be obtained.

Table 7. Comparison of telephone alternatives to radio.

Advantages	Telephone: Multipoint Private Line	Telephone: Switched Network Line	Telephone: Radio Telephone	Radio
Installation Ease	Good	Good	Good	Poor
Portability	Poor	Poor	Good	Good
Reliability	Good	Best	Fair	Fair
Message Capacity	Good	Fair	Poor	Good
Availability	Poor	Good	Fair	Best
Simplicity of Operation	Good	Good	Poor	Poor
Estimated Cost per Use 1/ (construction costs not included)	$220	Normal Call Routing: $120 Rotary (hunting) System Call Routing: $325	$500 to $1,800	$1,260 (based on one use per year)

1/ Appendix Table A5 shows how these costs were derived.

Table 8. Comparison of radio options for a service network.

Technical Advantages	Single Sideband	Microwave	Low Band FM	High Band FM	(Recommended) UHF FM
Radio Path Reliability	Poor (Difficult to establish; requires multiple frequencies)	Good (Complex initial design; subject to atmospheric disturbance)	Fair (Subject to destructive "skip" interference)	Excellent (Design effort minimal)	Excellent (Design effort minimal)
Size of Accessories	Poor (Large, heavy and bulky)	Good (Small and compact, but delicate)	Poor (Large, heavy and bulky)	Good (Small and fairly compact)	Best (Very small and compact)
Frequency Availability	Fair (Definitely limited, but available)	Good	Good	Poor (Very limited and almost unavailable)	Good
Estimated Cost	$2,000 per system	Greater than $10,000 per system	$4,500	$5,700	$6,800

Table 9. Comparison of radio with wire intercom for intracamp communications.

Advantages	Wire Intercom	Short Range Radio
Installation Ease	Fair	Excellent
Station Portability	Poor	Excellent
Reliability	Good	Good
Emergency Communications	Poor	Poor
Estimated Cost*	$600	$600

*Appendix Table A6 contains details of the cost estimates.

B. LARGE FIRE TELECOMMUNICATION REQUIREMENTS

1. EMERGENCY COMMUNICATION REQUIREMENTS

> In emergency situations, fire line personnel assigned communications equipment must be able to communicate directly with air support and with other ground personnel who can reasonably provide help.

The requirement to provide fire line personnel with access to all fire line communication networks is based primarily on the general undesirability of "pockets" of fire line or air attack personnel being isolated from other fire fighters because of incompatible communication channels. Such personnel must depend on chance verbal relays for establishing communications links; while such a situation must exist in the absence of technological means to prevent it, it ceases to be tolerable when technological means become available at a reasonable cost.

A tabulation in Table 10 (page 61) of past communication difficulties on large fires, based on questionnaire responses (Question 7, Appendix B1, page A42), shows that incompatibility of equipment ("different frequency") and lack of equipment ("no radio") represents a substantial cause of communication breakdowns in air-ground communications. An increased number of fire line communication channels, as envisioned in the proposed large fire communication system, will aggravate this condition if no compensating system requirements are made. The requirement that all parties assigned communications equipment be able to communicate directly with one another in an emergency would remedy difficulties arising from the use of multi-frequency equipment on a fire. The possible misuse of direct communications between all parties requires operator discipline to prevent channel congestion.

The problem of insufficient fire line communication links has been presented in numerous fire reviews and memoranda, especially with regard to the safety of fire crews. This work will be reviewed in detail in connection with tactical communication requirements of fire crews.

Table 10. Cause of fire line communication difficulties by percentage of selected large fire questionnaire respondents identifying each cause. (More than one cause per respondent.)

Respondent Position	Topography	Congestion	Different Frequency	No Radio	Other*
Fire Boss	54	73	0	0	4
Line Boss	62	48	10	38	19
Air Attack Boss	35	53	41	53	76
Division Bosses	92	67	22	59	67
Helicopter Boss	41	65	6	12	6
Sector Boss	86	97	26	80	20
Crew Boss	41	72	19	96	24

* Includes items such as:
Other end doesn't monitor
Radio failure
Background noise
Poor transmission, etc.

2. COMMAND COMMUNICATION REQUIREMENTS

The fire boss, line boss, air tanker boss (air tanker pilot in his absence), helicopter boss and division bosses need a direct and reliable means of communicating with each other, the fire camp, and the spike camps. This "command channel" must provide transmission capabilities between points along the entire fire perimeter and must include provisions for communicating over rough terrain.

Congestion of fire line communication channels has been identified by the large fire questionnaire respondents as the most frequent cause of breakdowns of fire line communication systems during multi-division and serious multi-fire situations (Table 10 page 61). No large sample measurements of fire line communications, per se, were made in the course of this study, and no direct evidence about the degree of congestion of the fire line communications system was obtained beyond that presented in the Forest Radio Net Study [1]. This study shows levels of observed network congestion during a monitored multi-division fire episode in Region 5 to have ranged from .34 to .63, indicating moderate to very heavy network use. The average observed level of congestion of .53 represents capacity network use.

Computations presented in the next section, based on incidental measurements of fire line communications traffic for a limited number of calls, show the proposed command channel utilization would also be at the .5 level (due in part to the transmission of air-fire line communications over this channel). Additional ground communications traffic within the divisions and ground to helicopter traffic must therefore be accommodated on a separate channel(s).

The requirement to use the command channel as the communications link between air attack (air attack boss and lead plane pilot) and fire line overhead is based primarily on the following fire line communication needs:

a. The need to satisfy fire line safety requirements by providing direct lines of communication to aircraft in an emergency.

b. The need to eliminate duplicate equipment and numerous network interfaces within the fire line communication system.

The requirement is <u>not</u> based on air net congestion considerations. Air attack to fire line traffic represents generally less than one-fifth of all air attack communications traffic. For the Pumpkin Creek fire, Bighorn National Forest, communications between the air attack boss and top line positions occupied approximately 15% of the available time (nine minutes out of each hour of operation), representing approximately 17%

of the entire communications traffic monitored (monitored from the main fire camp radio center). For periods of sustained helitack operations on the Quail Creek fire, Siskiyou National Forest, the air attack boss and helicopter boss communication traffic occupied approximately 16% of the available time, and represented, over the two periods combined, 21% of the monitored communications traffic (appendix, Table A7, page A10). Measurements from lead plane tapes, as itemized in the Appendix Tables A8, A9, A10, and A11 on pages A11 through A26, yielded values of 4.6% of all available time for air to line communications (2.8 minutes out of each hour of operation). This represents 6.6% of the total communications traffic monitored. The lead plane measurements did not, however, record all air to line traffic.

The chief link in air to fire line communications is between the air attack boss (or lead plane pilot in his absence) and the line boss. The line boss participates in a considerable proportion of all top line overhead communications. He is physically unavailable for ground communications when occupied by air attack communications and this somewhat minimizes the impact of air coordination traffic on the command channel.

The identification of the specific positions to be linked by the command channel --and those to be linked by other channels -- was based on the percentage of large fire questionnaire respondents indicating a need for a direct link to a specific contact (Question 6, Appendix B1, page A42). This information is summarized in Table 11 (page 64) for the main categories of fire line and air attack positions requiring direct communications over the command channel. The solid line brackets command communication links, while the dashed line brackets tactical communication links. An overlap exists for the division boss, line scout, and helicopter boss positions.

The responses summarized in Table 11 were evaluated against the expected "use information" provided by the same questionnaire (Question 1, Appendix B1, pages A40, A41). This "use information" is summarized in Table 12 (page 65), and gives the percentage of those respondents showing one or more calls to a contact. The two main groupings are about the same by both methods.

The command channel requirement for transmission capabilities over rough terrain is based on the reported high frequency of communication difficulties due to topography (Table 10, page 61) and interview information. The need to provide reliable communications along the entire fire perimeter, and to rough topographical areas of the fire perimeter, makes it necessary that one channel provide complete coverage of the fire. Practical hardware limitations and the need to keep division and sector transmissions localized whenever possible preclude the use of more than one channel with long range transmission capabilities on a given large fire.

Table 11. Percentages of large fire questionnaire respondents showing need for direct communication links for selected positions. (Solid line brackets command communication links.)

From \ To	Fire Boss	Line Boss	Air Attack Boss	Div. Bosses	Line Scout	Sector Bosses	Crew Bosses	Squad Bosses	Heli.	All	None specified, Blank
Fire Boss	x	70	37	11	-	4	-	-	-	11	4
Line Boss	27	x	77	68	18	5	-	-	5	5	-
Plans Chief	63	42	-	17	-	-	-	-	-	4	17
Fire Behavior Officer	30	50	10	10	10	-	-	-	-	-	40
Safety Officer	25	17	-	8	-	8	-	-	-	17	8
Air Attack Boss	5	65	x	30	-	5	-	-	30*	20	5
Helicopter Boss	12	29	53	18	-	12	-	-	59	12	12
Division Boss	11	59	22	22	19	37	4	4	11	7	11
Line Scout	7	13	20	40	x	27	7	7	7	7	20
Sector Boss	3	8	6	50	11	-	23	3	3	8	19
Crew Boss	3	3	6	6	9	39	9	27	12	-	24
Tanker Trucks	-	21	-	7	-	28	7	-	-	-	43
Tractor Boss	5	19	-	14	-	19	5	-	-	5	48

*Direct communication link between air attack boss and helicopters provided by air to air communication channel.

Table 12. Percentages of questionnaire respondents reporting calls to selected positions. (Solid line brackets command communication links.)

From \ To	Fire Boss	Line Boss	Air Attack Boss	Div. Bosses	Line Scout	Sector Bosses	Crew Bosses	Squad Bosses	Heli.	All	None specified, Blank
Fire Boss	x	100	81	48	19	11	-	-	26	-	-
Line Boss	82	x	100	95	64	45	5	10	59	-	-
Plans Chief	87	71	29	21	25	4	-	-	21	-	-
Fire Behavior Officer	60	80	40	60	10	30	-	-	-	-	-
Safety Officer	45	54	27	54	9	27	18	-	9	-	-
Air Attack Boss	50	100	x	70	10	35	15	-	65	-	-
Helicopter Boss	41	76	100	82	-	35	18	6	100	-	-
Division Boss	41	100	85	78	67	78	26	-	59	-	-
Line Scout	7	60	27	67	(13)	73	7	7	13	-	-
Sector Boss	11	31	31	94	39	64	83	8	22	-	-
Crew Boss	9	15	30	30	24	64	42	67	18	-	-
Tanker Trucks	21	36	7	64	7	93	64	7	14	-	-
Tractor Boss	10	40	5	50	30	55	30	5	10	-	-

3. COMMAND CHANNEL UTILIZATION REQUIREMENTS

The command channel must remain uncongested. The total number of airborne and ground stations assigned to this channel on a multidivision fire, including all those enumerated previously, should not exceed twenty.

The requirement to limit the number of primary users of the command channel during multidivision fires is based on projected communication traffic loads. These projections are based on limited direct observations and on fire questionnaire responses. The command channel must also be able to accommodate secondary users who will use the channel for emergency calls.

The observed average lengths of calls (Table 13, page 67) and average numbers of calls (Table 14, page 68) are based on monitoring slightly fewer than eleven hours of general fire line communications traffic (three division fires), six hours of fixed wing air to fire line coordination communications traffic and six hours of helitack traffic. This traffic was monitored variously during the Burns Creek (August 26), Quail Creek (July 15-16), Safety Harbor (July 18), and Pumpkin Creek (August 19) fire episodes in Regions 6 and 2 during 1970. The monitoring took place during the morning hours on the Pumpkin Creek and Safety Harbor fires, and during the afternoon on the Quail Creek and Burns Creek fires. At the time of monitoring, the Quail Creek fire was close to control but with helitack operations in progress, the Burns Creek fire was in the build-up phase, and the Pumpkin Creek and Safety Harbor fires were in the suppression phase with fixed wing air attack in progress.

On the basis of the foregoing, Tables 8 and 9 would represent a composite of communications traffic during a busy twelve hour day shift on a three division fire with air attack and helicopter activities. Used in this way and augmented somewhat by questionnaire data, the tables provide the basis for the computation of the command channel traffic loads shown in Table 15, page 69. The table shows that the traffic generated by approximately fifteen command channel users during air attack and helicopter operations would preempt slightly over one-third of the available channel time (22.6 minutes per hour, giving a probability of congestion of .38). Without air attack and with reduced helicopter activities (one half of the helicopter calls) the total busy time would amount to 13.9 minutes per hour, giving a probability of congestion of .23. On a five division fire the number of calls is estimated at 36 per hour when air attack is in progress, giving a probability of congestion of .48, corresponding to a busy time of 28.5 minutes per hour [2].

The computations indicate that during air operations the command channel can accommodate only a very limited number of users beyond those enumerated in Table 15 (page 69). As a general rule, the number of ground stations on the command channel should be limited as, for example, in Table 16 (page 70.)

Table 13. Average* length of calls (in seconds) for specific links, based on four fires in 1970.

LINK	Fire Boss	Line Boss	Air Attack Boss or Lead Plane	Heli. Boss	Div. Boss	Plans Chief	Eq. Man.	Other Fire Camp	Grnd.	Row Ave.
Fire Boss	x	66	49	-	44	-	46	20	-	52
Line Boss	66	x	56	135	58	48	77	43	38	64
Air Attack Boss or Lead Plane	49	56	x	37	-	-	-	36	-	46
Heli. Boss	-	135	37	x	98	-	-	38	30	51
Div. Bosses	44	58	-	98	-	47	42	33	44	42
Column Average	55	66	50	74	61	48	55	36	38	50 **

* Averages based on calls initiated by either party.

** Over-all average based on all (198) calls: 50 seconds
(Average length of call between Fire Boss, Line Boss, Air Attack Boss -lead plane pilot-and Division Bosses: 61 seconds)

Table 14. Observed number of calls per shift, command net links. Based on four fires in 1970. (Estimated average number of calls by questionnaire respondents shown in brackets).

FROM \ TO	Fire Boss	Line Boss	Air Attack Boss or Lead Plane	Heli. Boss	Div. Bosses	Plans Chief	Fire Camp	Other Grnd.	Other Air	TOTAL
Fire Boss	x	4 (13)	4 (4)	(-)	1 (3)	- (0)	2 (6)	-	-	11 (26)
Line Boss	4 (7)	x	10 (16)	4 (-)	14 (18)	7 (0)	10 (10)	3	-	52 (51)
Air Attack Boss or Lead Plane	4 (2)	25 (19)	x	5 (-)	- (13)	- (-)	22 (1)	-	x	56 (35)
Heli. Boss	- (3)	4 (7)	10 (-)	x	3 (9)	- (-)	7 (11)	9	-	33 (30)
Div. Bosses	2 (6)	6 (27)	- (15)	-	- (15)	- (-)	15 (21)	12	-	35 (84)
Plans Chief	-	10	-	-	1	x	-	-	-	11

TOTAL -- 198 (226)

Table 15. Estimated command channel load during a three-division fire.

Position	Est. No. Calls per Shift	Est. Length Shift (Hrs)	Est. Calls/hr. w/ Air Attack	Av. Length Call (Sec.)
Fire Boss	12	12	1	52
Line Boss	52	12	4	64
Div. Bosses	48*	12	4	42
Recon. Scout	-	12	1	38
Air Attack Boss/ Lead Plane Pilot	56	6	8	46
Helicopter Boss/ Heliport	36	6	6	51
Plans Chief	11	12	1	48
Fire Behavior + Saftey Off.	11	12	1	50
Fire Camp to Other Sites	24	12	2	36

No. of stations (3 division fire): 15

Average call length: 48.5 seconds

Average number of calls per station per hour: 1.86

Total busy time: 1,358 seconds/hour

Probability of congestion: .38

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* Adjusted upward in line with questionnaire responses.

Table 16. Example of ground stations using the command channel on multi-divisional fires without serious congestion.

Location	No. of Stations
Fire Boss	1
Line Boss	1
Division Bosses	up to 6
General Scouts	2
Helicopter Boss	1
Heliport	1
Fire Camp Console	1
Plans Chief	1
Spike Camps	2
Fire Behavior Officer	1
Safety Officer	1
	18

4. <u>COMMAND CHANNEL SEPARATION REQUIREMENTS</u>

> A minimum of three command channels are needed on a nationwide basis to allow for the separation of simultaneous fire communications within the radius of ground radio interference. Different command channels must be clearly marked for easy identification.

The requirement for multiple command channels is based on the necessity to minimize radio interference between fires, during multifire episodes, and between zones, on zoned fires. Both situations may occur simultaneously, as was the case on the Wenatchee fires during 1970. In order to determine the required number of channels on a national basis, an analysis was made for the four worst fire months on certain high fire incidence forests in Regions 1, 4, 5 and 6 (Appendix Exhibit B2, pages A51 through A83). The period of analysis was 1960-1970. Fires that were size E or larger and lasted longer than one day (Appendix Table A12, page A29) were assumed to require a project type organization and command channel capabilities. The sample forests were chosen to lie roughly within an area over which radio interference on a repeater channel could be expected. The results are shown in Table 17 (page 72). Out of the total sampled 298 worst fire days, a three channel capability for the command net would have provided interference free communications for all fires during 271 days, or 91 percent of the sampled days. Included in the count are necessarily some class E and F fires that may not have required organizations larger than one division. However, we assume that a call for cache radios would have included a call for a command channel which would then be unavailable on another fire.

Table 17. Number of days with up to three (four) fires of size class E* and larger expressed as a percentage of all such fire days. Eighteen sample forests, four worst fire months, 1960-1970, by regions.

Sample Forests in Region	No. Days w/ 1,2, or 3 Fires E or Larger	% of All Days w/ Fires E or Larger	No. Days w/ 1,2,3 or 4 Fires E or Larger	% of All Days w/ Fires E or Larger
R-1	91	100	91	100
R-4	69	100	69	100
R-5	64	95	64	95
R-6	47	66	60	85
Overall		91		95

* Class E fires burning a single day are not included in the count.

5. TACTICAL COMMUNICATION REQUIREMENTS

A minimum of three tactical channels are required to provide intra-division communication links between division , sector, and crew bosses, and various specialists at sector and crew levels. Line-air coordination with helicopters must also be accommodated by these channels.

The following analysis of communication requirements, focused on sector and crew bosses, is developed from four sources:

1. Previous Determinations

2. Expert Opinions

3. Direct Observations

4. Simultaneous Large Fire Statistics

Discussion of Previous Determinations

The sector organization is the basic unit by which the fireline is constructed. The sector boss is a line officer who must translate suppression objectives into the "nuts and bolts" direction of men and tools in "close to the fire" activities. This hazardous work is becoming more complex as the amount and kind of specialized equipment used in fire suppression increases. Decisions made at the sector level directly affect the safety of fire-fighters on the line, and also the quality of effort towards fire suppression.

It has long been recognized that radio communication is essential for the safety of sector members. As early as 1957, a task force concluded that communication was not adequate on most tragedy fires. In 1967, another task force found that "Standards for radio communication between line overhead have not been established" [3]. These are important points. It is common practice to equip the line overhead down through the sector boss with radios, all on a single channel. Fire line communications within the sector organization is a matter for local decision -- fire by fire. There is controversy among fireline officers concerning which, if any, additional positions should be added to the fire radio network. Some qualified overhead still resist providing certain components of the sector with communications, while reports prepared for the chief's office (by fire control personnel) stress the need for positive communication within the sector in order to improve crew safety and fire fighting effectiveness. "Nowadays, for the sector boss to direct his unit is indeed a challenge, and dependable communication is his

useful tool. Unfortunately, communication in the sector has not kept pace with demands. More positive communications is needed between the important components of the sector " [4]. "We believe it is desirable that the crew boss be equipped with radios to communicate with adjacent crew bosses and his superior....In addition, helicopter support of ground forces engaged in fire construction or line holding should be directed by localized ground forces -- preferably the crew boss....communication between the strategic line scout....is needed with the sector boss and/or crew boss" [3]. Contrast these statements with replies to the large fire questionnaire (Appendix Exhibit B1, pages A39 - A41, A47 - A48) received from division and sector bosses. Only 67% of the division bosses, who replied, felt the sector boss had an essential need to communicate with his crew bosses. Eighty-one percent felt that helicopter to sector boss communication was not essential. We believe these replies are indicators of three effects; (1) a lack of communications standards for the standardized line overhead organization, (2) a lack of overhead experience with adequate intra-sector radio communications, and (3) a fear that if bosses within the sector are able to talk to others over a distance they may shirk their "walk the line" responsibilities.

In the five years that the above quoted fire control objectives have been in print, there has been little tendency for line overhead to increase radio communications within the sector. Granted that adequate equipment was probably not available much of the time, it still seems that fire fighting organizations do not understand or appreciate the full potential of radio communications.

Safety has been the major reason for providing intra-sector communications, and rightly so. Increased efficiency of fire fighting crews by the proper use of radio is often not considered. The Office of Emergency Planning reported to the Congress,"....(radio service) will play an increasingly important role in maximum and economic utilization of manpower and equipment... The four most common communication problems were found to be: (1) overloading or saturation of available frequencies, (2) difficulty in the interlinking of separate frequencies, (3) lack of uniform procedures and terminology, and (4) inadequacy of equipment presently in use " [5].

Following the work of the Loop Fire Analysis group and the Fire Safety Review team in 1967, the Divisions of Fire Control and Administrative Management attempted to develop a Service-wide Universal Intra-sector (UIS) net. As noted in the report, "The objectives of this net are to provide:

1. Intra-crew communications between crew boss and squad boss;

2. Capability for crew bosses and sector bosses to direct helicopters dropping retardant;

3. Direct communications between adjacent crew bosses in critical areas;

4. Communications between the sector boss, his crew bosses, his sector scouts and helicopters assigned to his sector;

5. Uniformity of sector radio equipment for use on fires anywhere in the country;

6. An auxiliary channel capable of operating on the regional or zone fire cache frequency;

7. A lightweight unit with sufficient power to cover the range of a typical mountain fire sector;

8. The above facilities without unduly burdening the fire communications networks already in use" [4].

The UIS net has been studied, to some degree, but full development was curtailed. "The economics and feasibility of incorporating these (all fire control communications) into the Forest Service system is unclear...it became obvious a study of the overall communications system was needed...." [6].

It can be seen that the general intra-sector communication needs have long been known and justified. This study did not attempt to re-evaluate the requirement as stated in the preceding sources. We must answer questions that pertain to kinds, amounts and coordination of fireline communication. "There is not always agreement in the definition of adequacy. Some inadequacy of communications is often blamed for fire fighter casualties and failure to meet standards of fire control " [7]. The following is the question we have asked ourselves; "What are adequate intra-sector communications for personal safety and fire fighting effectiveness?"

Chain of Command Considerations

> Direct communications through the chain of command should be provided between the division boss, the sector boss, and the crew boss and, in special instances, the squad boss.

The above need has been explicitly stated in the preceding section. It will promote safety and firefighting efficiency. It is also supported by the opinions of qualified division, sector, and crew bosses as the analysis of Large Fire Questionnaire responses shows (Table 18, page 82.) The responses concur with the existing practice of providing radio links down the chain of command through sector bosses. Needs for intra-sector communications are not as distinctly recognized.

Table 18 indicates a paradox. Line overhead believes communications required for themselves to subordinates is a greater need than for their subordinates to them. For example, 85% of the sector bosses say they need a link to their crew bosses, while only 42% say crew bosses need the same link. Interestingly, 80% of the crew bosses say they need the link to their sector boss (about the same percentage as sector bosses that say they need the link to crew bosses). Perhaps this indicates that fire overhead can recognize their own needs more easily than they do the needs of others.

Opinions are also quite diverse among sector and crew bosses concerning squad boss radios. Seventy-three percent of the crew bosses express the need for squad boss radios, while only 23% of the sector bosses agree. Apparently there are some misgivings on the part of experienced fireline officers about providing radios to crew bosses and (especially) to squad bosses. "If my sector bosses can talk to their crew bosses, I am concerned that they may neglect their duty to walk the line and as a result, rely too much on the opinions of their crew bosses," paraphrases the opinions of some division and line bosses interviewed. There is apparently some concern that an unacceptable amount of extraneous talk will take place, generally lowering the efficiency and productivity of the crew boss.

In no case, from the monitoring of fireline communications, did we find the use of radio communications detrimental to the efficiency of the fireline organization. Instead, when intra-sector radios were supplied to four sector organizations on the Safety Harbor, Burns Creek, and Gold Ridge Fires (Appendix Table A2, page A3), we found increased productivity and effectiveness. This was apparent both from our monitoring and post shift interviews of bosses.

Thirty-two crew bosses responded to the large fire questionnaire. They answered unanimously that radios were desirable. Their reasons are summarized below:

1. Increased efficiency and effectiveness due to reduction in unnecessary work, ability to make rapid changes in line location, the ability to move to critical spots, faster shift change and the ability to extend crews along the line.

2. Psychological improvement (morale) due to increased awareness of the fire situation, feedback from their boss, and information transfer at shift change.

One-third of the crew boss respondents were able to give estimates of increased line construction that might result from adequate communication. These estimates ranged from 20% to 50%.

An example of increased line construction came at the Gold Ridge Fire, Wenatchee National Forest, Region 6. At about 1100 hours on August 26, 1970, one of the sector bosses, equipped with an intra-division radio by this study group, requested a felling crew from his division boss. The crew arrived on the sector at approximately 1230 hours. Without the radio a runner would have had to be used (travel time to division boss approximately 2 hours) or, more likely, no felling crew would have been ordered. The felling crew increased the sector productivity by approximately 200 - 300%. In fact, a sufficiently wide line could not have been constructed without the felling crew.

Generally, there is no need to categorically provide all squad bosses with radios. In most line situations the physical proximity of squad and crew bosses would not warrant adding squad bosses to the radio network. However, there are cases where intra-crew communications can be very productive. Such cases would include situations where: crews are extended over long distances, visibility is poor due to smoke or cover, line construction, line location, and scouting are simultaneous, and, of course, in hazardous conditions where immediate knowledge of fire behavior affects crew safety.

All things considered, there should be immediate, direct communications between the division boss, the sector boss, and the crew boss. There should be a direct link between the crew boss and the division boss for chain of command access whenever the sector boss is unavailable.

Selected squad bosses should have radios in special instances, at the discretion of the command organization.

Adjacent Unit Considerations

> Direct communications should be provided between adjacent crew bosses, adjacent sector bosses within each division and between adjacent crew and sector bosses in adjoining divisions.

As previously stated, direct communications are required for coordination of crews working toward each other. Qualified division, sector, and crew bosses support this requirement as shown in the large fire questionnaire.

Results of questionnaire responses are shown in Table 19 (page 83.) The itemized responses are shown in Appendix Table A13 (page A30). Division bosses seem to believe it is desirable for all their sector bosses to communicate directly with each other; yet, they evidently feel direct links to adjoining divisions are not essential. This may be a reflection of their attitude of general responsibility for intra-divisional activities, and they therefore feel the direct link between divisions should be at the division boss' level.

The sector bosses generally see advantages in having direct links with their next door sectors, whether within the division or not, and perhaps do not see any detrimental effects in having direct links into another division.

The opinions of the sector and division bosses show: 1) direct links between sector bosses (and division boss) within the division are essential; and 2) links between adjoining sectors in adjacent divisions are also essential, but can be indirect, with the division boss as the direct link.

Sector bosses see intra-sector crew boss communications requirements essentially the same as they see their own need to talk to intra-division sector bosses (32% and 33%, respectively). A lesser number of crew bosses believe links to other crew bosses are required. This may be because communications are essential only in hazardous conditions.

Sector Specialist Considerations

> Direct links should be provided between sector specialists, sector bosses, and the division boss to insure coordination and flexibility in sector assignments.

Direct communications between specialist positions such as felling bosses, tanker bosses, tractor bosses, and their sector boss are as essential as any of the groups of persons engaged directly in line construction or holding. Again, it is a matter of personal safety of these people and the efficient use of their efforts. These positions tend to be rather mobile, perhaps moving from sector to sector, or across sector lines. They are high cost, and highly productive units when effectively used. Coordination of their efforts with one or more line organizations demands information and communication links with all involved sector bosses and, generally, the division boss.

Other specialists must be considered in determining inter-sector communications needs. The line scouts can be working at various levels of the organization. Their intelligence must be provided to the proper officer. The firing boss has his own critical needs with

the other line personnel, and vice versa. There may also be other kinds of specialists involved at some time or another in sector activities. Any communication system must provide the means for integrating these positions into the radio network.

Table 20 (page 84) shows the specialist communication links which are essential, according to various respondents to the fire questionnaire.

Division bosses say that the sector boss to specialist link is much more essential than do sector bosses. This may indicate sector boss inexperience with specialists; usually it is the division boss who coordinates this function. The intra- and inter-sector network must make provisions for all specialists, when required.

Helicopter Line Support Considerations

> Positive communications should be provided between helicopters and sector bosses and crew bosses when the helicopter is providing direct line support within the sector.

This need has already been determined by Fire Control. Discussions in this section as well as discussion of air attack communications affirm this need.

It is interesting to note, however, that less than one-quarter of the sector boss and division boss respondents feel that the sector boss-helicopter link is essential (Appendix Table A13, page A31). Twenty percent of the crew bosses feel crew boss-helicopter communications is essential, while only three percent of the sector bosses agree.

The sector and crew boss consensus that a helicopter link is not essential may be attributable to their lack of experience with such a link or with direct helicopter support.

Specialized Crew Integration Considerations

> Provision for integration of organized crew radio networks into the intra-sector fire line networks should be made. Such crews often possess their own networks.

Intra-regional crews are trained to function as semi-independent units or as components of larger fire fighting organizations. Historically, many of these crews have possessed their own communications networks, and it is reasonable to assume that this may be an increasingly common situation. It is essential that their communications be standardized to be compatible with the large fire communication networks, specifically, at the sector level.

As opportunities present themselves, it would be desirable to coordinate the development of inter-agency fire fighting crew communications in the anticipation of cooperative fire fighting endeavors.

It is necessary that our large fire communications system, particularly that network serving the sector and crew level units, be designed so that specialized crew communications may be integrated into it.

Network Load Considerations

> The sector and crew level network should be designed to accommodate no more than one complete standard division organization consisting of: the division boss, three sector bosses, nine crew bosses and up to nine sector, crew or division specialists.

An estimated tactical channel load was determined from responses to questionnaires and from direct fire radio traffic observations, and is shown in Table 21 (page 85). This sample division has 19 positions using radio communications. The estimated numbers of calls per shift per link shown in the table are from questionnaire responses of 24 division bosses, 31 sector bosses, 32 crew bosses, and 14 line scouts. The average length of call for specific line position links was determined from three electronic monitoring episodes in 1970. The average length of call for sector specialists was inferred from the average length of call for all line positions. The number of calls per shift was converted to an estimated number of calls per hour during the busy periods of the shift.

The workload of 19 stations in the network results in an estimated average call length of 34 seconds, and an average number of calls per station per hour of 2.33. This generates a total busy time of 25.1 minutes per hour, which gives a probability of congestion of .42. This congestion figure is well below the proposed maximum tolerable level of .66 [1], and therefore should allow slack for the introduction of sector to helicopter communications during periods of tactical helicopter support. The average length of time the call-initiator would have to wait because the line was busy would be less than one minute [2]. From the large fire questionnaire responses, 100 percent of our sector and crew bosses would be satisfied if the maximum delay time did not exceed two minutes 90 percent of the time. Seventy percent would be satisfied if the maximum delay never exceeded 4 minutes 90 percent of the time. It is reasonable to assume that the sample network, with an average delay of less than one minute, is adequate in terms of network congestion and tolerable delay time.

Three tactical networks, consisting of up to 21 positions plus helicopters, should provide satisfactory communications well within the desired limits of congestion. The number of required tactical channels is determined from computed communication traffic loads, and by the need for separation of communications traffic on different divisions, especially during helitack activities. A minimum of two non-repeater tactical communication channels are needed when channel separation must

be achieved between sectors. A third tactical channel will aid three or more division fires on terrain where two channels will not provide channel separation between divisions.

Table 22 (page 86) shows the number of fires in the Western Regions for which the estimated manning was one or more division, for the fire years 1960, 61, 66, 67, 68, and 70. These were the worst total burned acreage fire years of the decade (figure 9, page 87). The division estimates were based on reported size of fire, fire duration, and the general regional vegetative and terrain characteristics. The computed average number of divisions on a multi-division (2 or more) fire was 3.1.

Twenty-nine percent of the multi-divisional fires required four or more fire fighting divisions. Assuming that on only one half of the fires requiring four or more divisions, interference-free communications could be achieved using three tactical channels, eighty-five percent of all multi-division fires would have satisfactory tactical communications. Since the above assumption seems conservative, a three channel tactical communication system should satisfy the requirement for interference-free divisional communications.

Table 18. Essential communication links within the chain of command. Affirmative replies from respondents expressed in percentages.

LINK	PERCENT OF AFFIRMATIVE REPLIES Division Bosses	Sector Bosses	Crew Bosses
Division Boss to Sector Boss	96		
Sector Boss to Division Boss	88	94	
Sector Boss to Crew Bosses	67	85	
Crew Boss to Sector Boss		42	80
Crew Boss to Squad Bosses		23	73

Table 19. Essential communication links between line units. Affirmative replies from respondents expressed in percentages.

LINK	Division Bosses	Sector Bosses	Crew Bosses
Sector Boss to Intra-Division Sector Bosses	50	33	
Sector Boss to Adjacent Sector Bosses	21	58	
Crew Boss to Intra-Sector Crew Bosses		32	27

Table 20. Essential communication links between line and specialist positions. Affirmative replies from respondents expressed in percentages.

Sector Boss to:	Division Boss	Sector Boss
Firing Boss	79	33
Felling Boss	58	39
Line Scout	50	39
Tractor Boss	67	36
Tanker (pumper) Boss	58	36

	Line Scout
Line Scout to	
Sector Boss	61
Line Scout to	
Crew Boss	6

Table 21. Estimated channel load within a three sector division, generated by the chief channel users.

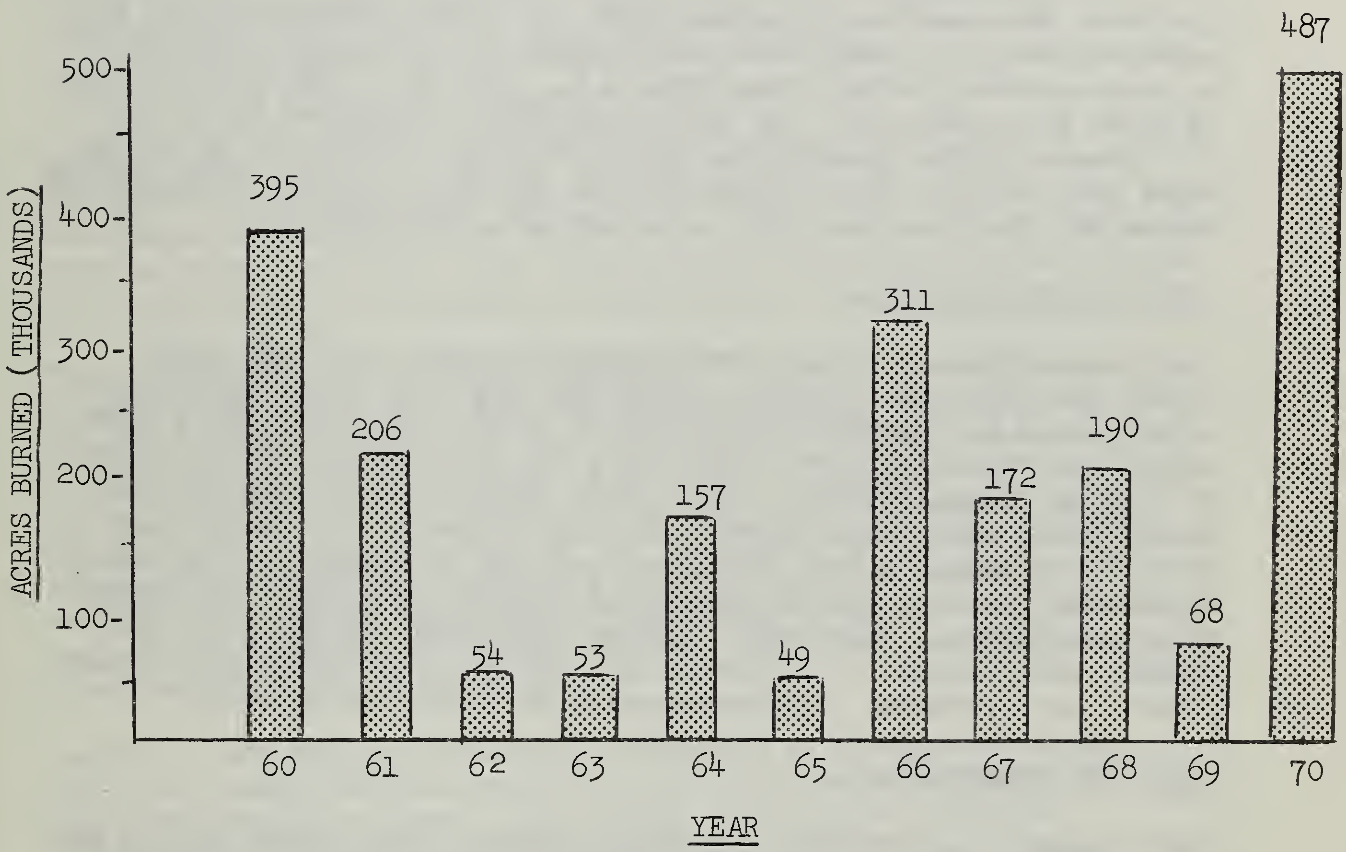
INITIATOR	(#)	RECEIVER	Est. No. Calls per Shift	Est. No. Calls per Hour	Average Length calls (sec.)
Division Boss	(1)	Sector Bosses	27	2	37
Sector Bosses	(3)	Division Boss	27		49
		Sector Bosses	30		31
		Crew Bosses	24		32
		Sector Specialists	6		27
		ALL	87	6	37
Crew Bosses	(9)	Sector Bosses	63		39
		Crew Bosses	9		21
		Sector Specialists	6		27
		ALL	78	18	36
Sector Specialists	(6)	Sector Bosses	6		27
		Crew Bosses	6		27
		ALL	12	12	27
TOTAL	(19)		204	38	34

NO. STATIONS :19
AVERAGE CALL LENGTH :34 secs.
AV. NO. CALLS/STAT./HR. :2.33
TOTAL BUSY TIME :1505 secs./hr., or 25.1 min./hr.
PROBABILITY OF CONGESTION : .42
AVERAGE DELAY TIME :less than 1 min.

Table 22. Estimated number of fires with indicated number of divisions for the fire years 1960, 1961, 1966, 1967, 1968, and 1970.

	No. Divisions								
Region	1	2	3	4	5	6	7	8	9
R-1	20	24	15	4	0	3	0	0	1
R-2	9	3	2	1	-	-	-	-	-
R-3	8	7	6	5	1	1	-	-	-
R-4	9	25	7	3	6	1	-	-	-
R-5	5	20	17	13	2	2	1	2	2
R-6	11	17	7	8	2	2	1	-	-
Total	62	96	54	34	11	9	2	2	3

Figure 9. Total acreage burned, by year (1960-1970), in Regions 1 to 6.



6. AIR TO AIR COMMUNICATION REQUIREMENTS

> A minimum of four, and more adequately, six, single frequency air to air communication channels for close range communications are required to separate areas of concurrent sustained slurry drop operations within radio interference distances.

The requirement to provide several short range air-to-air communication channels is based on the volume of air-to-air communications during slurry drop operations and on the incidence of separate fires burning simultaneously within radio interference distances. The volume of air-to-air communications traffic during air attack is too heavy to allow adequate communications when interference from other fires is permitted.

The basic data sources for fixed wing air attack communications were tape recordings of lead plane communications during such operations as on the Safety Harbor (Wenatchee N.F., July 18), the Pumpkin Creek (Bighorn N.F., Aug. 19), and the Slide Ridge (Wenatchee N.F., Aug. 27) fires of 1970. Transcripts and strip charts (Exhibits B3 and B4, pages A84, A85) of these tapes yielded the data shown in the Appendix Tables A8, A9, A10, A11, A15, A19, and A26, respectively.

Efficient Channel Use

From transcripts of taped communications between the lead plane pilots and air tankers making retardant drops, we found operations to be guided by a meticulous effort to obtain the best result from each drop. This effort was frequently not efficient from the point of view of communications, but it does agree with the present retardant drop procedures wherein the lead plane pilot directs each drop. To recommend a more efficient pattern of communications would apparently require some thoroughgoing changes in present retardant drop organization. This might involve additional training for retardant drop pilots, a different role for the air tanker boss (lead plane), and, perhaps, the introduction of drop site markers.

Field Recommendations

Field reports, interviews, and questionnaire data, suggested the need for a range of 2 - 8 air attack communication channels. The lowest suggested number of channels envisioned the use of two non-repeater channels. The following quote characterizes many of the comments received:

> "Remove the repeat system, use two channels with proper zoning, use 122.9 at helispots, and 75% of the confusion could be eliminated. This, however, would have still been an overload on the system."

Monitored Air Attack Communications Traffic

Figure 10, page 93 shows the overall communication load for four three-hour periods of intensive slurry drop operations on the Safety Harbor, Pumpkin Creek and Slide Ridge fires in 1970. Involved in the operation over each specific drop area was an air attack boss and/or lead plane pilot and from five to eight air tankers, together with approximately four helicopters. With minor fluctuations, communications traffic for the air attack operation comprised sixty-eight percent of the available time (entire time of observation). Considering only periods of air tanker slurry drop activity, the observed air attack communication traffic occupied seventy-five percent of the available time. Air tanker lead plane coordination alone required fifty-five percent of the available time during such periods. All of these figures represent a very high degree of channel utilization during air attack operations. These are tolerable only because the link between the air attack boss, lead plane pilot and the single air tanker making the slurry drops is essentially private. Congestion becomes acute only in the case of competing users from other fires. On monitored fires, when a possibility for competition existed, the study team invariably found that the users were separated by recourse to borrowed FAA frequencies, such as 122.8 and 122.9. The justification for such action is clear from the amount of air attack communications traffic observed.

The characteristics of the monitored air attack operations are shown in Table 23 (page 94). The average spacing of flights is a measure of the intensity of the over-all air attack operation. It is computed by dividing the total observation time (from the start of the initial slurry drop operation to the end of the last one) by the recorded number of flights. For the three monitored fires, the average air tanker time over the fire was eight minutes and the average turn around time (including ground time) was one hour and ten minutes. The Pumpkin Creek fire was the most intensive of the observed air attack operations.

Despite considerable differences in attack characteristics, the observed communications traffic was fairly constant (Table 24, page 95). The lead plane - air tanker contact time averaged thirty-seven percent, the air attack-lead plane communication traffic averaged eight percent, and air attack boss to helicopter communications traffic averaged six percent of the available time (entire time of observation). Observed fluctuations were generally due to specific circumstances associated with the fire situation, such as poor flying conditions (Slide Ridge Fire).

Table 24 (page 95) shows that even if air to ground traffic were eliminated from the channel (average of 8.5 percent of available time), interference from adjoining fires, if allowed to occur, would cause intolerable difficulties.

Air Communication Interference Distances

Air communication interference evaluations are based on engineering computations assuming no repeaters and taking into consideration the elevation of the craft over the terrain, the signal strength and the position of the two craft forming the communication link.

Two kinds of interference can arise:

1. Destructive Interference

2. Nuisance Interference

Destructive interference occurs when an undesired signal has captured a receiver and the receiver cannot be recaptured by a desired signal. This occurs, in general, when the undesired transmitter is less than twice the distance from the receiver compared to the desired transmitter and, in addition, has the same transmitted strength and frequency as the desired signal. When the distance to the receiver is greater than twice the distance from the desired transmitter nuisance interference exists, but the receiver can be captured by the desired transmitter. Nuisance interference will occur from the point at which destructive interference stops to the limit of the receiver sensitivity (Table 25, page 96). Differences in signal strength between the desired and undesired signal will not be discernible to the signal recipient unless the signal is so weak that the resulting audio output is masked by inherent receiver noise. This can only occur at received signal levels of less than 1 or 2^{uv} (assuming a typical receiver in a moderately high radio frequency noise environment).

The maximum distance between two stations with 25 watt transmitters, at which signal levels of 2^{uv} or less would be present at the receiver (considering only free-space attenuation), would be 1550 miles.

Incidence of Fires Within Radii of Radio Interference

Figure 11, page 97, shows cumulative percentages for fire days with one or more fires size E or larger (singly and in combination) for several areas in Regions 1, 4, 5 and 6 (Appendix Tables A14 through A19 on pages A32 to A37). The areas selected extend over 250 to 300 miles; this represents the practical limits of air to air radio interference. In each region, data were obtained for four high fire occurrence months for two or more of the severe fire years: 1960, 1961, 1966, 1968 and 1970. The graphs show that in the Region 5 sample area ninety-one percent of the 46 fire days had fewer than six simultaneous fires size E or larger (curve B2 of fig. 11, page 97). Ninety percent of the 117 fire days in an area covering parts of Regions 1, 4 and 6 experienced eight or fewer simultaneous fires within a 150 mile radius circumscribing the area (curve B1 of fig. 11). For the Gifford Pinchot, Snoqualmie, Wenatchee and Okanogan National Forests combined, ninety percent of the fire days studied involved fewer than seven simultaneous fires of size E or larger.

The overall average (curve A1, fig. 11) also shows ninety percent of the fire days with fewer than seven simultaneous fires size E or larger. The ninetieth percentile for the sampled fire days thus ranges from six or fewer to eight or fewer simultaneous fires size E or larger.

The evaluation of simultaneous fire occurrences is based on reported fire durations from detection to control. The number of active simultaneous fires for air attack purposes must be assumed to be somewhat lower. The limitation to fires size E or larger is based on the assumption that air attack on simultaneous smaller fires would not involve the number of planes and the sustained intensity encountered on larger fires. Such activities would represent a diversion from the air attack activities on the larger fires. This assumption follows, in part, from limitations imposed by the size of the air tanker fleet and air tanker facilities.

Impact of Size of Air Fleet

At present, the Forest Service has under contract 76 single and multi-engine air tankers including one air tanker owned by Region 6. Based on past experience, the maximum number available in one area during even the largest conflagrations did not exceed thirty air tankers. While air activity was limited on the Southern California fires by high winds, the number of available air tankers during the period of September 20 to October 15 at Burbank and Hemet airfields was 23 (10 at Burbank and 13 at Hemet). On September 28, 1970, eighteen air tankers were assigned to six fire areas in California, two of which, in Central California, were outside the radio interference range with Southern California. On September 29, according to Aviation Week and Space Technology [8], there were 27 air tankers active on all major fires in southern and central California.

During the height of air activities on the Wenatchee National Forest on August 17, 1970, the fires were served by a total of 19 aerial tankers (11 at the Pangborn airfield and 8 at the Omak airfield) with 6 available lead planes at the two airfields. Thus no more than 6 simultaneous fixed-wing air actions, involving 3 air tankers each, could have been sustained even with the much larger number of possible targets present. It is probable that no more than four simultaneous air tanker actions could have been sustained with the planes and ground facilities available. The air net and three FAA frequencies were in fact used (Appendix Exhibit B5, page A86).

Other limiting factors such as smoke and wind conditions often reduce the scope of air attack activities during severe fire situations. During the very critical fire conditions of 9/25 - 10/2, 1970, wind conditions limited the use of aircraft in southern California. Smoke conditions similarly limited the use of aircraft during most of the multiple-fire situation on the Wenatchee National Forest during 8/22 - 9/5, 1970.

On the basis of the above discussion, six air-to-air communications channels are the maximum presently required to provide interference-free air-to-air communications during simultaneous air attack activities on fires within radio interference distance of each other. Taking the limitations placed on present air attack facilities into account, four non-repeater air-to-air communication channels constitute the minimum necessary for interference-free communications. The latter number of air to air channels will require the continued use of occasional additional frequencies during severe fire situations. With the growth and improvement of air attack facilities, additional air to air channels will be required. The air-to-air communications system should allow for such expansion.

NOTE: Since no air-to-air communications equipment will be on the fire line, air-to-air communications channels won't be preempted by ground traffic as noted in this field comment concerning air net use on the Entiat fire:

> "...When the air cleared of smoke to the point that the use of aircraft was possible, the air net frequency was so cluttered that the line organizations abandoned it in favor of their less-cluttered line frequencies. To emphasize this point, six new air net PT-400's were dispatched to camps 1, 2, and 3 in factory-fresh cartons. The same six air net radios returned to Zone Communications Headquarters at the Entiat Ranger Station two days later untouched."
>
> "Two properly zoned simplex air net frequencies would have solved many of the ground-to-air problems for the line organizations."

Figure 10. Air attack communications and Air Tanker - Lead Plane contacts as a percentage of (a) all available time for the entire period of observation, (b) retardant drop intervals only, and (c) periods between retardant drops.

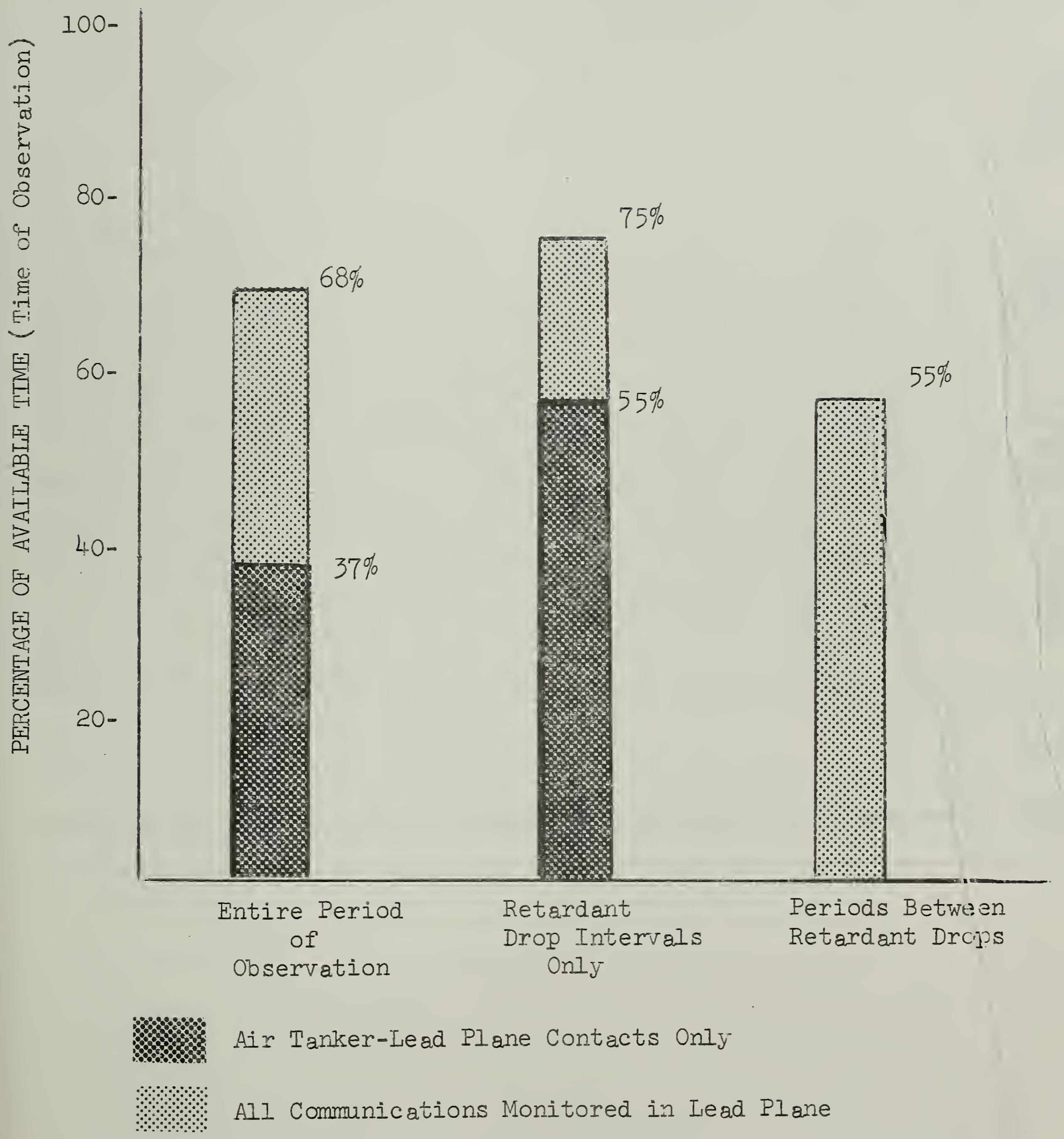


Table 23. Observed air attack flight characteristics.

Fire	Observ. Time (hrs)	Air Tankers (No.)	Tanker Flights (No.)	Av. Spacing of Flight (min)	Av. Tanker Time Over Fire (min)	Turn Around Time (hrs)
Safety Harbor 7/18/70 (5:30 am)	2.57	5	9	17.15	8.85	1.66
Safety Harbor 7/18/70 (10:30 am)	3.15	5	12	15.75	10.33	1.25
Pumpkin Creek 8/19/70	2.48	7	18	8.28	5.30	0.90
Slide Ridge 8/27/70	2.63	8	13	12.10	6.82	0.86
Average				13.32	7.82	1.17

Table 24. Components of Lead Plane monitored air attack communications expressed as percentage of all available time (time of operation).

Fire	% Lead Plane Air Tanker Contact Time	% A. A. Boss-Lead Plane	% A. A. Boss/Lead Plane Helicopter	% All Air-Air	% All Air Attack
Safety Harbor 7/18/70 (5:30 am)	33.2	12.5	3.7	49.8	74
Safety Harbor 7/18/70 (10:30 am)	32.7	3.2	4.1	40.1	52
Pumpkin Creek 8/19/70	37.8	10.7	8.1	57.1	72
Slide Ridge 8/27/70	44.8	7.4	1.1	53.5	76
Average	37.1	8.5	4.2	50.1	68.5

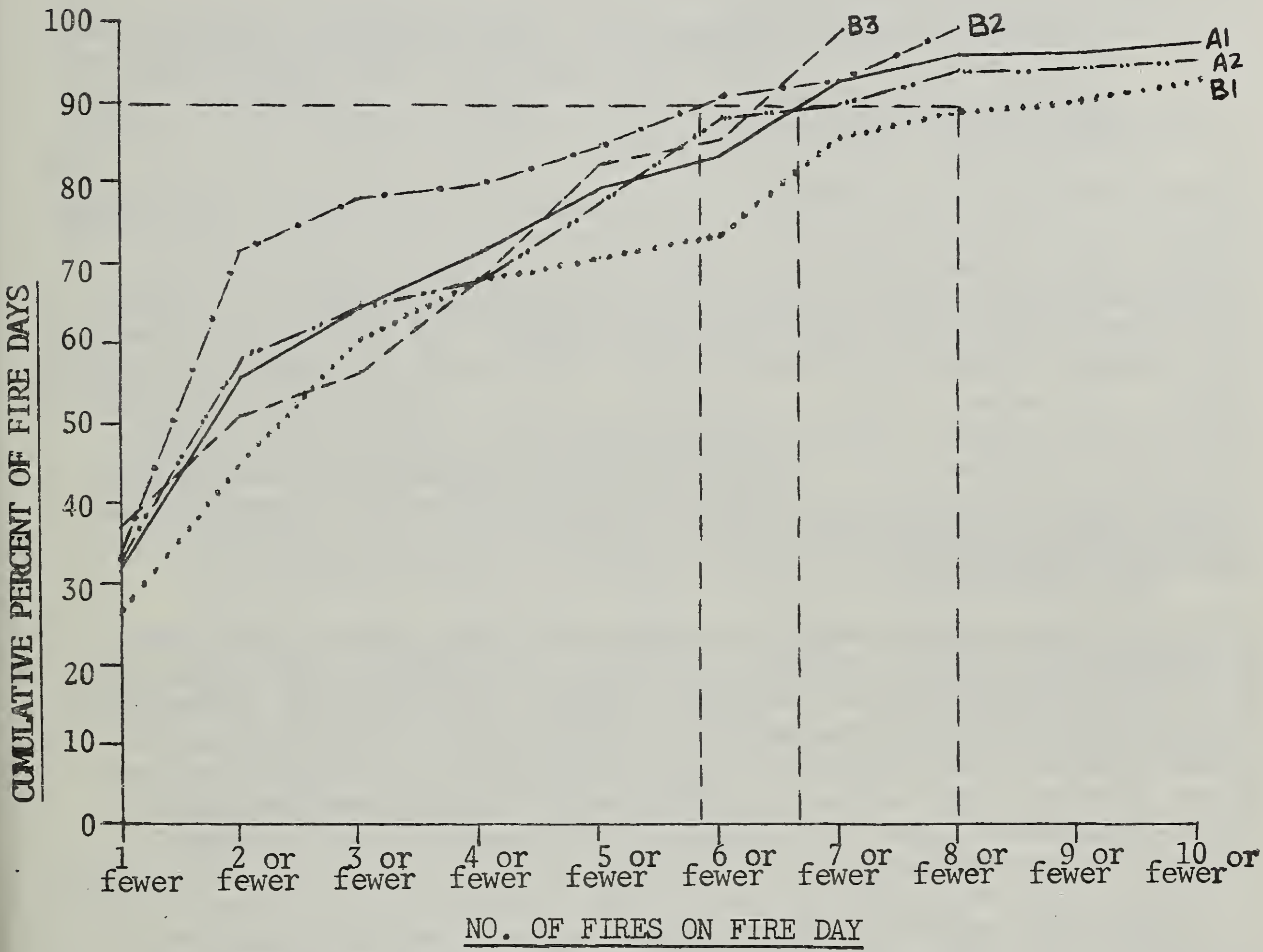
Table 25. Maximum line of sight radio path distances* for reception at 30 and above MH_z (considering a normal atmospheric refraction factor.)

Altitude of Receiver (ft. above terrain)	Altitude of Transmitter (ft. above terrain)	Line of Sight Distance - Miles
500	500	65
500	1000	75
500	2000	93
500	3000	106
1000	1000	87
1000	2000	106
1000	3000	120
2000	2000	125
2000	3000	140
3000	3000	155
5000	5000	200

----

* Assumptions:
a) Refraction factor of 1.33 (can and does range between 0.6 and 5.0)
b) No fresnel zone attenuation
c) Antennas are equally effective at all angles of signal incidence
d) Terrain: smooth earth surface, same at both points

Figure 11. Cumulative percentage of fire days, within areas of air attack radio interference, with up to the indicated number of fires, size E or larger, during four high fire months in the period 1960 - 1970.



Area Code:

B1 - Nezperce, Clearwater, Bitterroot, St. Joe, Wallowa-Whitman, Umatilla, Payette, Boise, Salmon National Forests (July, 1960; July, 1961; Aug., 1961; Aug., 1966)

B2 - Los Padres, Angeles, San Bernardino, Cleveland Nat. Forests (July, 1960; June, 1966; Sept. 1970; Nov., 1970)

B3 - Wenatchee, Gifford Pinchot, Okanogan, Snoqualmie Nat. Forests (Aug. 1961; Aug., 1968; July, 1970; Aug., 1970)

A1 - Average Cumulative Percentages for B1, B2, B3

A2 - Average Cumulative Percentages for National Forests listed in B1, grouped by Regions.

7. SIMULTANEOUS MONITORING REQUIREMENTS

The air attack boss and/or the air tanker boss and helicopters must be able to simultaneously monitor the fire line to air and the air-to-air communications traffic. Instrumentation for simultaneous monitoring is required. Air tankers must be able to establish air to air communications when operating under the direction of an air tanker boss or air attack boss and air to ground communications otherwise, but <u>do not</u> require simultaneous monitoring capability.

No person, without the support of a special radio operator, should have more than two "work channels" with simultaneous monitoring requirements. A "work channel" is one used in direct support of a specific activity.

In order to assure air safety, it is necessary that aircraft (fixed-wing and helicopters) working in the immediate vicinity of each other be in contact over a communications channel which is being monitored constantly while the aircraft is airborne. At the same time, it is necessary for the air tanker boss (lead plane pilot) and air attack boss to be in radio contact with the fire line for coordination and for ground safety. Air tankers under the immediate control of the lead plane would normally not require contact with the fire line. Such contact becomes necessary only when an air tanker is working independently and in such a case there would be no need for continuous air to air communications. Contact with air dispatcher would be maintained over a long range air communications channel.

At present, helicopters maintain contact with the ground through the helicopter boss and, on occasion, directly with the fire line personnel. The volume of such traffic is low at present, due mainly to insufficient equipment, but even so, the ability to monitor air to air and air to ground traffic simultaneously is required due to air safety considerations. Moreover, the volume of helicopter to fire line communications can be expected to grow with increased helicopter use and improved communication facilities.

An installation which allows efficient simultaneous monitoring is a necessity. All flying personnel interviewed indicated a strong belief that such equipment is essential for efficient operations. Indications are that the present situation places an intolerable burden on air attack personnel.

8. LONG RANGE AIR COMMUNICATION REQUIREMENTS

A long range communication channel is required for all fixed wing aircraft to serve as a communication link between the air dispatcher, air base, slurry base, and the aircraft.

A national standby channel, for use by all aircraft not temporarily assigned to a different channel, must be designated from among the available air communication channels.

This requirement is based on the need for a long range communications channel for ground-air support. Cargo, jump and transport planes are especially dependent on the availability of a long-range communications link. Because the long-range requirement conflicts with the intended local use of the air to air communications links, a separate channel may be provided to satisfy this requirement. The need for a separate channel is not based on the volume of communications. The measured communications traffic between air and ground support does not exceed four percent of the available time. Long-range transmission capabilities for use with the air channels may be more costly than separate facilities, however, and may extend the interference range of the air to air frequencies. The unintended use of air net repeaters was observed by the study team twice during the 1970 fire season.

A separate air-to-ground support communication channel may be required when operating from an uncontrolled airport during a large fire. In most of these situations the use of FAA frequencies would, however, seem preferable.

A permanently designated, year-round air communications standby channel, for use by all aircraft not temporarily assigned the use of another channel, is essential. The standby channel must also provide long-range transmission capabilities.

9. <u>SERVICE RADIO COMMUNICATION REQUIREMENTS</u>

> A single high quality service radio communication channel from fire headquarters to "outside" is required if adequate telephone service (including radio telephone) is not available. Verbal relays are not acceptable. A transmission range of 40 to 60 miles is required. The service channel should be available with the arrival of project overhead. Hard copy transmission equipment for transmitting lengthy messages such as supply orders and fire progress reports is required with either radio or telephone communication links.

Of the total communications load between the fire headquarters and the forest dispatcher or supervisors office, about 80% of the calls are of a service nature. The calls are long, averaging 9 minutes each (maximum of 50 minutes), and occur about 4 times per hour. This is in sharp contrast to the fire line calls which are very short (25 sec.) and much more numerous (Table 26, page 102). Radio use by line and service is in conflict and, except for unusual circumstances, cannot be satisfactorily carried out on the same radio net.

The large fire questionnaire (Appendix Exhibit B1, page A45) solicited suggestions for improved communications. A separate service net was the most frequently mentioned improvement by the overhead directly concerned with this problem. More radio channels and telephones were next. Together, these account for 62% of the total service suggestions (Table 27, page 103.)

The National Fire Supply Service meeting held at Boise in March, 1971, strongly recommended a separate link for supply and finance. The chief's office concurs with this recommendation in their memorandum of May 12, 1971.

The fire headquarters is seldom located more than 60 air miles from the forest dispatcher, or more than 40 air miles from the nearest telephone (Table 28, page 104.) More than half the fires studied had telephone or mobile telephone service at the fire camp.

Verbal relays are frequently established as the quickest and easiest way to communicate with the "outside" over steep terrain or long distances. Unfortunately, they have disadvantages that make it imperative to limit this method to the initial stages only. Each relay delays the message and increases the transmission time. Every verbal repeat increases the chance of garbling the message. After three or four oral relays most of the message is lost. An example of this occurred during the Okanogan fires of July, 1970. With four oral relays in the service link, the South Creek Pass fire had insurmountable problems in supply that lasted six days. It was reported that several crews would have deserted this fire because of inadequate supplies if they had known the direction to the road.

Service messages are of necessity detailed as to exactly what is being ordered and what is available. Questions on substitutions must be resolved at once. Rosters of incoming and departing personnel must be transmitted. The name, model and size of parts and supplies must be exact. Verbal relays are not adequate for this type of traffic.

Service traffic to the "outside" builds up rapidly in the early stages of a large fire. The peak seems to come on the first day after the project overhead arrives at the fire. This usually coincides with the shift from the forest net to a different communications network, and, with the mobilization of large amounts of men, equipment and supplies required for a project fire. The increase in service messages at the fire camp is illustrated by figures 12 and 13, (pages 105-106) while figure 14 (page 107) shows overall increase at the supervisor's office during a multiple fire campaign, Other examples are the Quail Creek Fire supply orders of July, 1970, Siskiyou National Forest, with the distribution shown in Table 29 (page 108.)

Service messages between the line and fire camp are limited and may be handled as a part of regular line to camp communications. Table 30 (page 109) shows the volume of this traffic for a four division fire (800 men) with one spike camp. The 24-hour average is 31 messages per day. During a five-day period, including the days cited in Table 30, 50 supply orders were placed as a result of line requests. This represented one service order for each three line messages received in camp.

Ideally, each fire camp needs two communication links to the "outside", one for service needs, and one for command, plans and public information, etc. In the absence of phones, this requirement can be met with one service radio net and the forest net. If telephones are available,

two lines would suffice. For larger camps (about 600 men) another line should be provided. Three phones proved to be adequate for camps up to 1400 men (Table 31, page 110.)

Of 31 fires studied, 16 had telephones and/or radio telephones in camp and 19 or 61% used it as either the only, or final link to the "outside."

Four respondents to the fire questionnaire mentioned the need for hard copy transmission. Three of these were dispatchers (Table 27, page 103). The latter are our most experienced people in message handling.

It is universal practice to write out the supply order at the fire camp. The order is again reduced to hard copy at the receiving end, an unnecessary process if hard copy transmission were used. Transmission of hard copy would eliminate the errors that inevitably creep in with each verbal repeat.

Messages misread over the air, garbled transmissions, misinterpretations and copying errors greatly increase air or wire time. There is also the potential for major incidents in misinterpreted messages.

Table 26. Number and length (in minutes) of service calls for some 1970 fires*.

Fire	Method	Calls/Hr.	Average Length	Max. Length	% Service Type Calls	Remarks
Quail Creek	1 radio telephone	1	13	14	All	This was a very busy party line. Separate radio-phone for non-service messages
Shrew Creek	2 radio telephones	6	NA	NA	80%	Satisfactory
Pumpkin Creek	forest net radio	5	3	50	80%	Satisfactory
Echo Valley	1 telephone	4	13	26	50%	Use considered light on this day
Soldier Creek	radio telephone	2	7	30	77%	Satisfactory

* Monitor and observation times selected for periods of heavy use.

Table 27. Suggestions for improved service communications by certain overhead personnel.

Suggestion	Fire Boss	Service Chief	Line Boss	Comm. Officer	Supply Officer	Dis-patcher	All	% of Total Responses
Provide a separate service net	8	14	7	6	10	10	55	29
Provide Telephone or radio telephone in fire camp	3	7	2	5	13	7	37	20
Provide more radio channels to sepa-rate functions	6	4	1	6	2	6	25	13
Improve procedures + training of operators	0	2	0	5	1	7	15	8
Provide intracamp net-CBI field phone	0	6	0	1	4	0	11	6
Provide more radios	0	1	1	4	0	5	11	6
Eliminate verbal re-lay of service mes-sages.	0	0	0	2	2	6	10	5
Provide more re-peaters	0	5	0	2	1	1	9	5
Provide teletype or hard copy service to fire camp	0	0	0	1	0	3	4	2
Reduce forest net traffic	0	0	0	0	0	3	3	2
Misc.*	0	1	0	0	0	6	7	4
Total	17	40	11	32	33	54	187	100

* Misc : radio-phone patch, more phones in SO, improve dispatcher facilities,hard copy equip.,use satelites

Table 28. Length of service link in miles, 1970 fires

Fire	Dispatcher*	Nearest Phone*	Remarks
Soldier	15	15	Mobile phone at camp
Deep	30	30	"
Cottonwood	25	25	"
Granite	20	20	"
Quail Creek	40	11	"
Shrew Creek	20	20	"
Williams Lake	40	6	Radio to phone
8 Mile	32	3	3 mile line laid in
Forks	31	0	Phone & mob. phone
East Creek	60	18	Radio to phone
Schallow Mtn.	16	0	Phone
S. Creek Pass	50	16	Radio to phone
Hungry Creek	48	2	FN & messenger to phone
Bunker Hill	62	40	Radio to phone
Hardy Mtn.	58	16	Radio to phone
Safety Harbor	44	0	Phone
Pumpkin Creek	42	8	FN phone not used
Mitchell Ck., Alta	48	0	Phone
Mitchell Ck., Ski	36	0	Phone
Slide Ridge	40	0	Phone
Entiat # 1	22	0	Phone
Entiat # 2	30	0	Phone
Entiat # 3	32	0	Phone
Entiat # 4	40	18	Radio to phone
Lake Wenatchee	32	0	Phone
Leavenworth	17	0	Phone
Average Distance	36	10	

*Air line distance as measured on forest map.

Figure 12. Radio-Telephone calls. Shrew Creek Fire, July, 1970.

1/ Overhead Team arrives A.M. 7/19

2/ Fire turned back to District. Controlled at 1000 hrs, 7/21

Figure 13. Service calls between GHQ and fire camps. Tonto Fires, July, 1970.

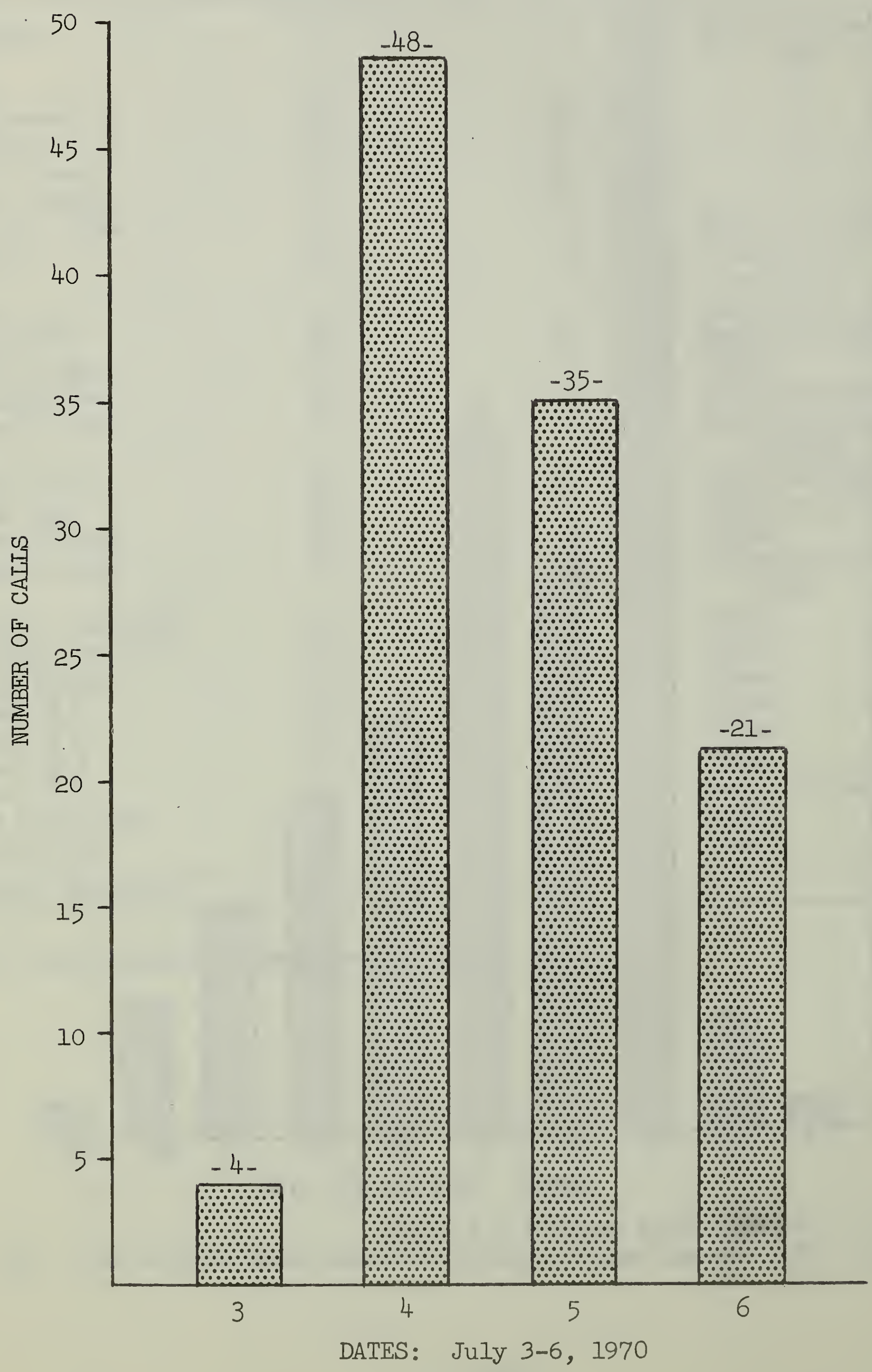


Figure 14. Build-up of long distance telephone calls, Okanogan Supervisor's Office (22 project & 80 small fires between dates shown.)

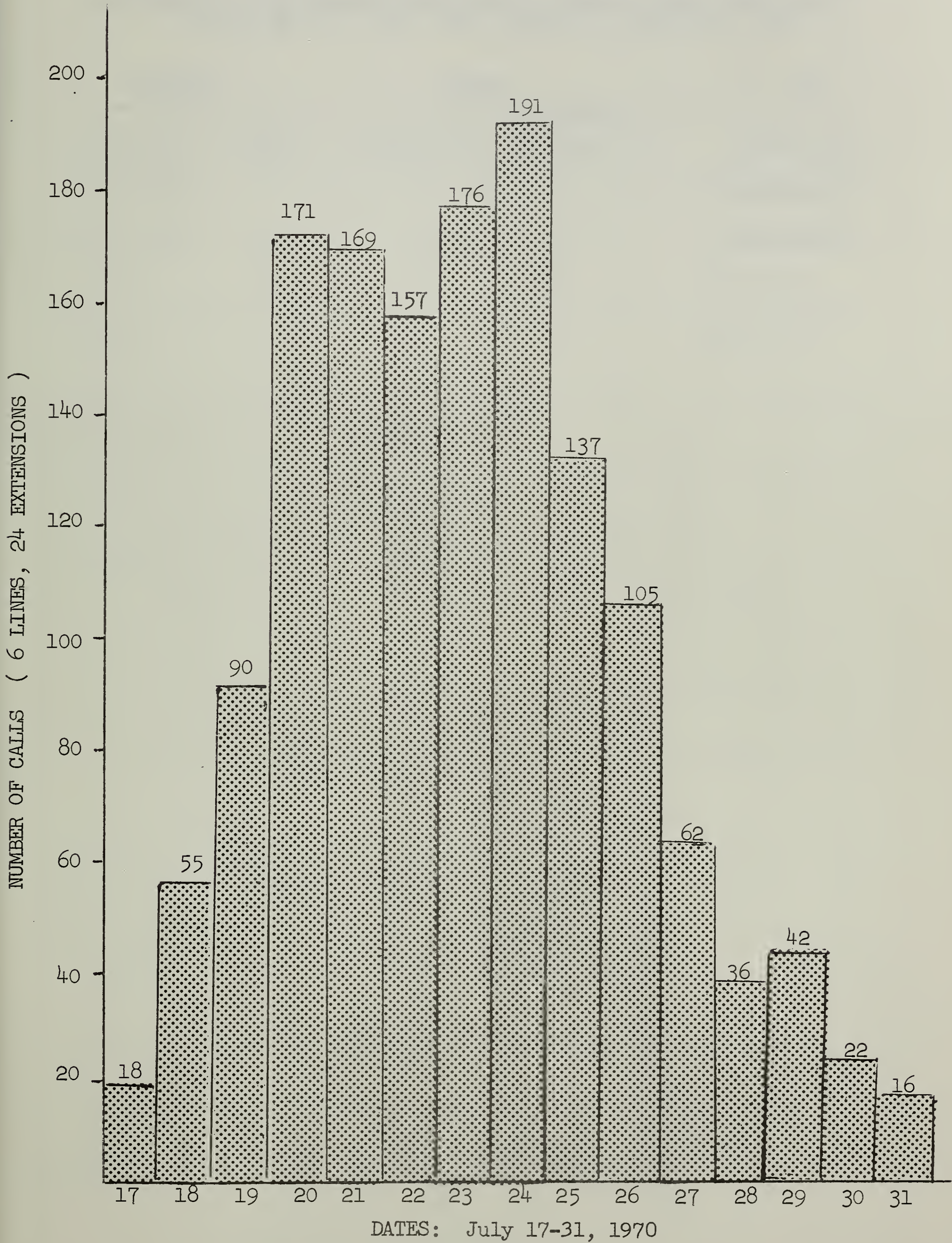


Table 29. Supply orders transmitted at Quail Creek Fire, 1970

DAY	NUMBER	PERCENT
First Day	27	55%
Second Day	18	37%
Third Day	4	8%

Table 30. Service messages relayed to fire camp from the line organization -- Alta Camp, Mitchell Creek Fire, 1970

Date	Total	Service	Spike Camp Messages	Time
8/26	70	26	0	1015-2400
8/27	103	36	2	0009-2400
8/28	71	25	6	0000-2400
8/29	9	2	1	0000- 705

Table 31. Telephone service on some 1970 fires.

FIRE CAMP	MANPOWER	TELEPHONES	TOTAL	COMMENTS
Entiat #1	1300	3 private	3	Adequate
Entiat #2	440	1 2-party 1 private	2	Inadequate
Entiat #3	1400	1 2-party	1	Adequate
Entiat #4	600	1 private	1	Adequate
Ski Camp	1300	1 5-party 1 private	2	Adequate
Alta Camp	800	3 private (12 available)	3	Adequate
Slide	1200	3 private	3	Adequate

10. FIRE CAMP COMMUNICATION REQUIREMENTS

A short range intracamp communications system is needed between the functional groups of plans, service and finance. When there is too much physical separation between service and its subunits such as the motor pool, supply officer, or camp officer, the system should be capable of being extended to them. Spike camps staffed with full time service personnel need a communication channel to the main fire headquarters.

The physical size of the fire headquarters on a large fire usually brings with it the separation of functions beyond unaided voice range or easy walking distance. The three functional groups of plans, service and finance have essential communication needs between them and with the fire boss (Table 32, page 112).

The above communications links were recommended by the National Fire Supply Service Meeting of 1971, and concurred with by the chief's office.

The need for an intracamp network was stressed by 11 questionnaire respondents, as shown in Table 27, page 103.

The small, on the line, spike camps usually have very limited needs to communicate and can often be served with the regular line to camp link.

11. SERVICE COMMUNICATION MANAGEMENT REQUIREMENTS

Service communications management needs to provide:

a. Trained operators

b. Clear and concise operating instructions for fire camp communications equipment.

c. Emergency step-up plans for the Supervisor's office message handling capabilities.

Most men selected as fire camp radio operators are unfamiliar with the equipment. Most operators get their training, if any, on the job. The need for trained operators and better procedures was mentioned fifteen times as a way to improve communications by the people closest to the problem. Communication officers and dispatchers account for twelve of these suggestions. One communication officer estimated a 50% reduction in radio traffic with trained operators and proper procedures (Table 27, page 103).

Some pertinent fire camp notes by a study observer on a fire in 1970 are quoted here from his field report:

"About half the time when plans chief, or fire boss and some others, come to make a call or take a message, they pick up wrong mike and call on wrong net. They then try the second or third mike. There are five sets on one table. Three are not readily distinguishable."

Table 32. Percentages of fire questionnaire respondents making essential calls to indicated locations. (Fire camp is presumed to include plans, finance and service functions.)

FROM / TO	FIRE BOSS	FIRE CAMP	HELIPORT
Fire Boss	X	59	30
Service Chief	50	45	65
Plans Chief	87	21	29
Helicopter Boss	41	41	53
Supply Officer	5	73	42

"Gas generator located 55 feet from outdoor communication table. Noise interference."

"Radio operator unskilled at beginning but improved. He had no conveniences, could not reach instruments while sitting."

"Communications table had no diagram of organization. No map or organization list to aid in identifying position or location of people calling."

Quoting further from the same source, "Our observations at headquarters camp were: (1) rarely was a note taken about any message; (2) many times the operator gave 10-6, left the radio in search of staff to supply the answer; and (3) it would be expected that many messages would be lost. The blame was not all on the operator. He seemed to do his best, but he had not been properly trained. He probably did not know there were printed instructions somewhere by which to train himself. Any one of six people at headquarters camp could have instructed him in five minutes. Solutions include: (a) recruit and train radio operators, (b) write detailed job descriptions for self-training".

Present communications centers on most forests (forest dispatcher offices) are generally designed for a one-man operation on a "normal" day. These centers are not equipped to handle a large multiple fire situation that requires many channels and operators. The rapid expansion of communication channels at the fires requires a corresponding increase in communication facilities at the forest communications center.

For example, the telephone directory of 8/27/72 for the Wenatchee fires (Appendix Exhibit B6, page A87) shows 24 phone numbers in the fire camps and ranger stations but only 16 phones in the Supervisor's office complex. The sixteen phones in the supervisor's office were used for "outside" calls as well as for the incoming calls from 24 fire phones. Rotary switching equipment was not used and delays of 1/2 to 1 hour on calls from camps was a universal complaint. The rapid expansion of the communication load in a Supervisor's office can be seen in Figure 14, page 107. The figure shows a tenfold increase in the number of long distance telephone calls from Okanogan Supervisor's office during the first three days of the Okanogan "bust" of 1970.

12. <u>FIRE CACHE REQUIREMENTS</u>

A national fire cache must be able to supply fifteen multi-division or multiple fires, simultaneously. Equipment is required to properly operate and control the ground communications system, and to implement the air communications system in unequipped aircraft. A three-day supply of batteries should accompany each module. The arrival of fire cache radio equipment on the fire should coincide with the arrival of the intended users (project overhead).

The estimates of needed command and tactical radio equipment modules are based on the incidence of multi-division fires and severe multiple fires, the length of turn around time for cache radio equipment, and the estimated average number of fire fighting divisions on multi-division fires. Table 33, page 115, shows the number of multi-division fires which occurred during the eight fire months of the worst five fire years of the decade, 1960-1970. The ninetieth percentile of the distribution of the number of fires for the twenty monthly periods of June, July, August, and September is at fifteen fires per month (Fig. 15, page 116). A detailed analysis of fire starts has shown that most of the fires occur within a narrow time interval of several days during each month.

Because estimated National Fire Cache equipment turn around times (Table 34, page 117) exceed the few days a month when most fires occur, equipment can seldom be shifted from fire to fire. Therefore, the size of the fire cache must be sufficient to supply fifteen fires simultaneously.

Using the previously estimated average (page 80-81) of 3.1 divisions per multi-division fire, times the above 15 fires, we obtain a requirement for 46 tactical communication modules. Each module should incorporate additional equipment to facilitate the transfer from day shift to night shift.

Table 35, page 118, shows an estimate of the numbers of tactical radio modules required to supply the communication needs during the worst twenty fire months in 1960-1970. The table shows that one out of twenty of the worst fire months would have exceeded the estimated level of forty-six cache modules. On this basis, the level of forty-six modules would supply ninety-five percent of the worst fire needs.

Battery procurement difficulties were mentioned to study observers during the 1970 fire season so repeatedly in the fire camps that it appeared radio communications were on the brink of collapse. Follow-up investigation uncovered the fact that only a few radios in about three locations were ever out of service due to lack of batteries. This is nevertheless a serious problem; improved battery supply management is a necessity.

Finally, a centralized fire cache is workable only if established management procedures and transportation facilities can assure that the arrival of cache equipment will coincide with the arrival of the intended users of the equipment. Present procedures often do not meet this test.

Table 33. Number of multi-division fires*, by month, for six Western Regions. Five worst fire years between 1960 - 1970.

Year	April	May	June	July	Aug.	Sept.	Oct.	Nov.
1970	0	1	1	10	17	13	0	3
1968	0	0	11	7	5	6	2	2
1966	0	1	11	14	12	8	0	3
1961	1	0	10	9	15	1	3	0
1960	5	0	10	39	15	4	3	0

*Condensed from Appendix Exhibit B7, pages A89 through A102.

Figure 15. Frequency distribution of monthly numbers of multi-division fires for 20 fire months, June-September, 1960, 1961, 1966, 1968, 1970.

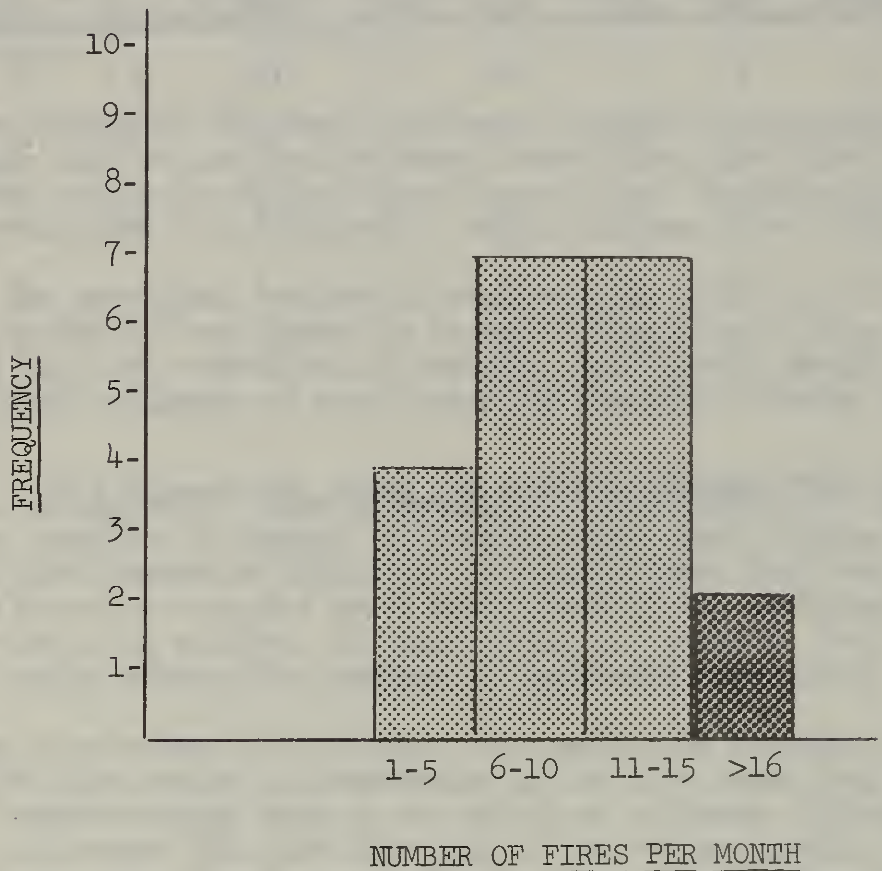


Table 34. Estimated* turn around times for National Fire Cache equipment. Fires class F and G.

Region	Average Turn Around Time, Days: Class F fires	Class G fires
1, 4, 6	22	29
5	16	22

*Based on actual fire duration times and estimated mop-up, shipping and maintenance times.

Table 35. Estimate of the numbers of tactical radio modules required to supply communication needs during the worst twenty fire months, 1960-1970.*

Year	June	July	August	September
1970	2	22	42	34
1968	28	12	19	9
1966	31	39	36	22
1961	27	29	38	4
1960	11	76	32	10

----

* Condensed from Appendix Exhibit B7.

13. EQUIPMENT STANDARDIZATION REQUIREMENTS

> Communications equipment in a national cache system should be standardized to facilitate use and to minimize types of batteries and other replacement parts needed at the fire. All fire communications equipment must be clearly marked for easy identification.

Standardization of the large fire communications systems should increase the familiarity of the operator with the system and thus increase system effectiveness. The communications officer would similarly benefit from system standardization and from a uniform identification of system components. As a secondary consideration, fire cache management would also be greatly aided by the above provisions.

A uniform and clear marking code for all fire communications equipment is essential to its effective use.

14. FIRE COMMUNICATION MANAGEMENT REQUIREMENTS

> The overall management of the fire line communication system, including assignment of channels and monitoring of the system, must be under the control of a designated individual with an understanding of the communications system and of the fire communication needs.

Large fire communications management represents a serious deficiency in present large fire communication systems. As these systems grow in complexity, proper management of the systems is indispensable if complete chaos is to be avoided. As a case in point, on the Slidge Ridge Fire four frequencies were too many; they were unworkable because of lack of management and were replaced with a two-frequency Boise Cache radio system on August 25, 1970.

Study team field observations have shown that a large percentage of fire communications personnel were not used to capacity. Communications Technicians frequently performed capably within the limited framework provided. However, many did not know whether or not they were designated as communication officers. Most expressed a need to be included in planning sessions and to be provided with better information on communication needs by the fire management staff. In many instances, especially at the Wenatchee fires, the technicians at the fire camp were able to handle the technical aspects of equipment management, but lacked the knowledge and experience to handle communications system management.

For a complex communications system fire communications management must provide the skill to anticipate needs, coordinate channel assignments, and supervise system use. In order to accomplish this task, one or more knowledgeable individuals must be clearly designated for the task. The individuals so designated must have access to the fire planning information necessary for communications planning.

The task of fire communications management may be combined with the task of system maintenance and implementation (electronics technician tasks) on smaller fires. On large multi-division fires system management will require the full attention of the designated individual.

Fire cache communications management must assure the arrival of requested equipment in the time provided. The matching of compatible components for a fire is a function of the fire cache management. Fire cache management must also assure the prompt return of fire cache equipment to the cache, or the reshipping of equipment to other fires.

15. SOUTHERN CALIFORNIA INITIAL ATTACK COMMUNICATIONS REQUIREMENTS

Southern California Forests have at least two major communications problems that are connected with their initial fire attack. These are:

1. Contact and control communications between fire overhead (district ranger and fire boss) and the forest dispatcher and ground tankers from other Southern California Forests.

2. Contact and coordination communications between cooperator overhead (Battalion Commanders and Fire Chiefs) and Forest Service overhead (District Ranger and Fire Boss).

Ground tankers (Class 1 and 2) dispatched from other forests often are not able to contact the forest dispatcher for instructions at the point of destination. No direct communications links with overhead, for the direction of tanker activity, is available at the fire perimeter.

Forest Service overhead at present have no direct communications link with cooperator overhead. This lack of communications makes it difficult to coordinate the initial attack activities during fluid and fast moving fire situations.

The large or project fire problems of the Southern California Forests (Angeles, Cleveland, Los Padres, and San Bernardino) are essentially the same as in other Regions. The proposed National Radio Cache, delivered within eight hours of request, and the proposed air communications system would solve these problems.

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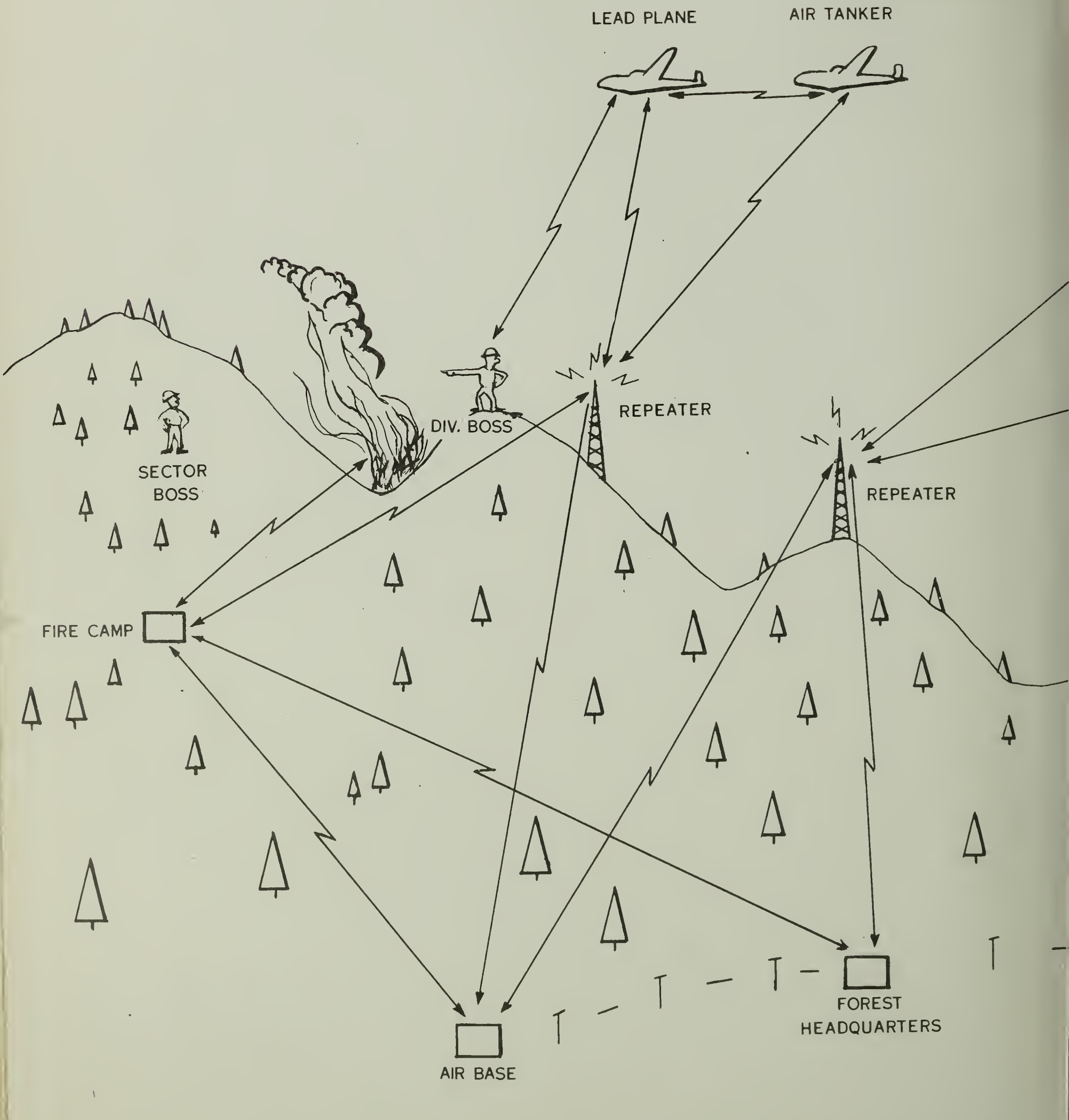
LEAD PLANE
AIR TANKER
REPEATER
DIV. BOSS
SECTOR BOSS
REPEATER
FIRE CAMP
FOREST HEADQUARTERS
AIR BASE

A STUDY OF
FOREST SERVICE
TELECOMMUNICATIONS

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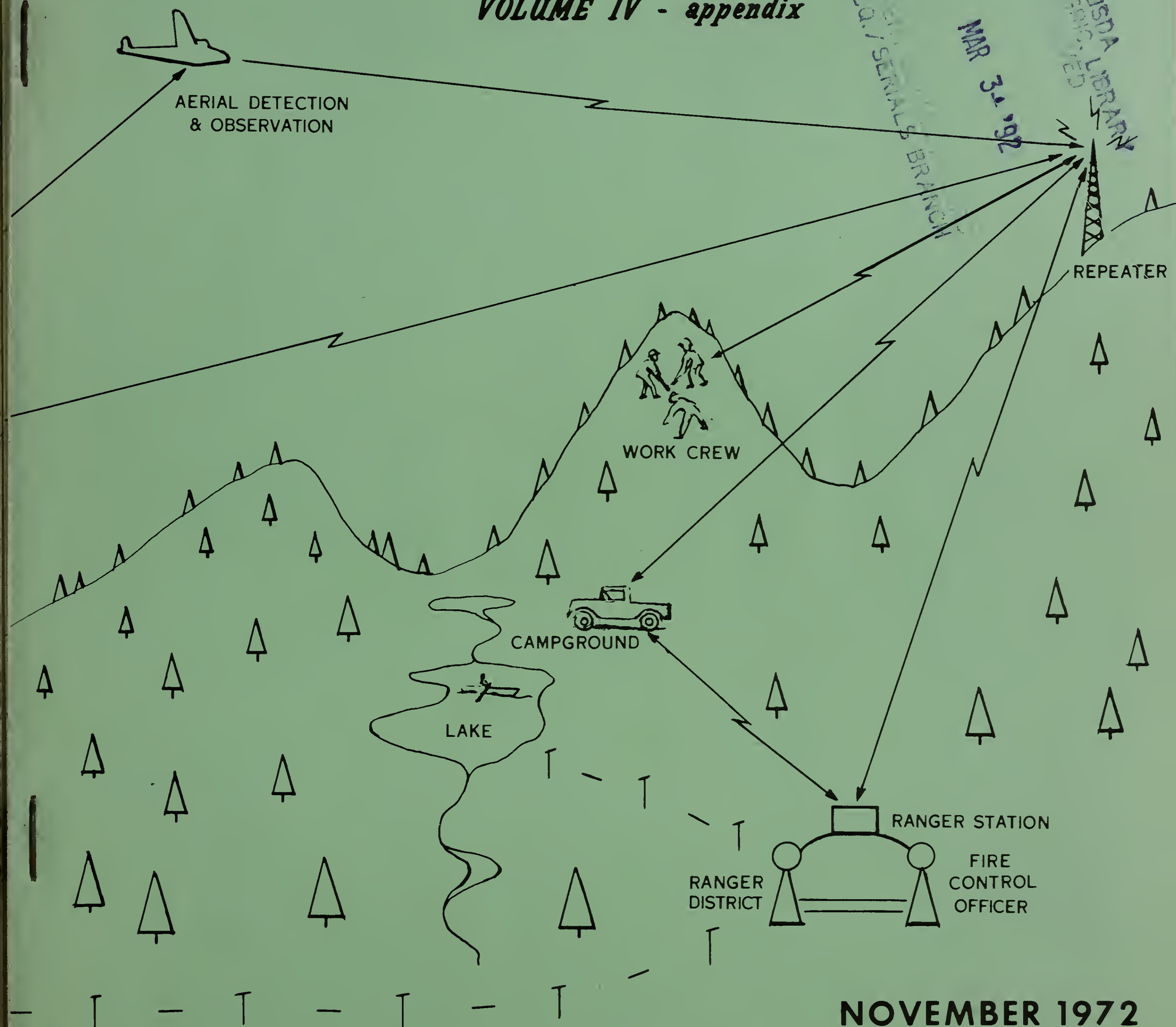

NOVEMBER 1972

FOREST SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

SERVICE-WIDE TELECOMMUNICATIONS STUDY

Volume IV

Large Fire Communications Systems

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November 1972

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B5. Sample of extra comment solicited in question 26 of the Large Fire Questionnaire.................. A86

B6. Wenatchee telephone directory, 1970 fires............. A87

B7. Monthly fire report and division unit estimates........ A89

Table A1. Project fires observed by Study Team, 1970 season.

Fire Name	Date	Region	Size	Max. Men.
Gila Multiple Fires	6/22	3	51 Fires	200
Soldier	7/3-6	3	Class E	469
Deep	"	3	" E	325
Cottonwood	"	3	" E	325
Granite	"	3	" E	60
Quail	7/15-17	6	2600 A.	700
Shrew Creek	7/16-31	6	145 A.	UNK
Williams Lake	"	6	650 A.	UNK
Eight Mile	"	6	75 A.	UNK
Honeyman	"	6	150 A.	UNK
Forks	"	6	61350 A.	UNK
Cougar	"	6	80 A.	UNK
East Creek	"	6	80 A.	UNK
Schallow Mtn.	"	6	1400 A.	UNK
S. Creek Pass	"	6	105 A.	160
Tripod	"	6	75 A.	UNK
Hungry Creek	"	6	200 A.	150
Show Creek	"	6	50 A.	UNK
Bunker Hill	"	6	2200 A.	UNK
Hardy Mtn.	"	6	35 A.	UNK
Safety Harbor	7/18	6	15000 A.	1400
Pumpkin	8/17-21	2	2500 A.	500
Mitchell-Alta Lake	8/24-9/8	6	43500 A.	800
Mitchell-Ski Camp	"	6	see above	1300
Slide Ridge	"	6	6630 A.	

Table A1. (cont.)

Fires	Date	Region	Size	Max. Men.
Entiat #1	8/24-9/8	6	15400 A.	1500
Entiat #2	"	6	14000 A.	1100
Entiat #3	"	6	13000 A.	1600
Entiat #4	"	6	2300 A.	600
Lake Wenatchee	"	6	1000 A.	500
Leavenworth	"	6	700 A.	500
Laguna Mtn.	9/26-28	5	150,000 A.	UNK

Table A2. Tapes recorded in summer 1970.

1.	Gila N. F. Dispatcher Service	6/28/70
2.	Tonto N. F. Air and Line Nets	7/5 & 6/70
3.	Siskiyou N. F. Lead Plane, P. M.	7/14/70
4.	Siskiyou N. F. Quail Creek Fire Line and Air Net	7/15/70
5.	Quail Creek Fire Service Net	7/15/70
6.	Quail Creek Fire Line and Intra-sector Nets Wayout Saddle Monitoring Stations	7/16/70
7.	Wenatchee N. F. Lead Plane	7/17 & 18/70
8.	Wenatchee N. F. Safety Harbor Fire Lead Plane	7/18/70 10:30 A.M.
9.	Wenatchee N. F. Safety Harbor Fire Cassette Tape 1	7/23/70 1430-1500
10.	Wenatchee N. F. Safety Harbor Fire Cassette Tape Intra-sector, CB	7/23/70 1550-1625
11.	Wenatchee N. F. Safety Harbor Fire Cassette Tape 3	7/23/70 1700-1730
12.	Pumpkin Fire Lead Plane	8/19/70 1830-2115
13.	Pumpkin Fire Side 1 GHQ Radio Center Side 2 Communications Center	 8/19/70 8/19/70

Table A2. (cont.)

14.	Entiat Fire	8/25/70
15.	Entiat Fire Channels 1 and 2	8/25/70
16.	Echo Valley Service Net	8/26/70
17.	Wenatchee N.F. Burns Creek Fire Cache - Line	8/26/70
18.	Wenatchee N. F. Lead Plane A. M. (Pangborn Field)	8/27/70
19.	Gold Ridge Fire CB Monitoring	8/30/70

Table A3. Number of aircraft* Requiring Large Fire Communication facilities.

Ownership Status	Type of Aircraft						
	Air Tankers	Lead Planes	Cargo-Jump**	Heli-copters	Other**	Observer**	Air Attack Boss
F.S. Owned							
R-1		1					
R-2		2	1		1		
R-3		4			3		4
R-4			4				
R-5		5	1		5		
R-6		5	5	1			
R-8							
R-9							
Contract							
R-1	11	2	8	15			
R-2	4			3			
R-3	12		3	16			
R-4	12	1		6			
R-5	15			24			
R-6	12		3	17			
R-8	1	2					
R-9	1						
Rental, Non **Contract**							
R-1				13		2	5
R-2	8			5		2	2
R-3				10		12	
R-4			1	5		5	
R-5				5			17
R-6				24		4	5
R-8							
R-9							
Totals	76	22	26	144	9	25	33

*Not adjusted for now-simultaneous use.

**Those normally used on large fires.

Table A4. Averages of productivity increase estimates by selected positions for good Large Fire Communications.

Position	Minimum Productivity Increase Estimate	Average Percent Productivity Increase Estimates	Nº Respondents Answering Ques
Fire Boss	15	30	7
Line Boss	25	38	2
Div. Boss*	20	25	4
Sector Boss	10	23	8
Crew Boss	20	26	7
Air Attack Boss*	25	58	4
Lead Pilot	NA	NA	0
Helicopter Boss	20	48	2
Air Service Officer	25	27	2

*One estimate excluded from computation of average.

Table A5. Radio and telephone cost estimates for service communications.

Radio costs per year:

a. Purchase cost $5700 amortized over 10 year economic life at 7%. — $ 810/yr.

b. Maintenance cost per year (3 units and accessories) — 450/yr.

Total — $1260/yr.

Telephone costs per year:

Option I

Multipoint private line with no construction costs.

Example: "Hot line" from fire camp to headquarters, 20 mile circuit.

a.	20 mi. @ $6 per circuit mile per month	$ 120
b.	Installation	100
	Total	$ 220

(This estimate is subject to great fluctuation depending upon the situation.)

Option II.

Switched network line with no construction costs

a. Four single lines; normal call routing

Monthly charge	$ 20
Installation	100
Total	$120

b. Four single lines; hunting call routing, "key" telephone and four extensions.

Monthly charges	$ 95
Installation	230
Total	$325

Table A5 (cont.)

Option III:

Radio-telephone

These costs are virtually impossible to predict. The costs have ranged from $180 to $50 per day per unit. An example for a 10-day rental period would be:

@ $180 per day $1800

or @ $ 50 per day $ 500

Telephone Construction Costs:

Construction costs are subject to great fluctuation depending upon the terrain, heavy construction tools available, etc. Pacific Northwest Bell has estimated $0.50/ft., or about:

$2500 per mile

Actual observed construction costs have ranged from:

$200 to $1000 per mile

Table A6. Initial cost comparison of three intra-camp communication systems

1. Wire intercom		
a. 10 master stations		$550
b. 11 conductor cable 200 ft.		50
	Estimated Total	$600
2. Public address system		
a. Amplifier and microphone		$150
b. Projector speakers		100
	Estimated Total	$250
3. Low-cost, short-range radios		
a. 10 each @ $60	Estimated Total	$600

Table A7. Air-fire line and helitack communications traffic on the PumpKin Creek (Bighorn N. F., Aug. 19, 1970, GHQ) and the Quail Creek (Siskiyou N. F., July 15, 1970) fires.

Links	Pumpkin Creek Fire*		Quail Creek Fire, 7/15/70**		Quail Creek Fire, 7/16/70***	
	Nº Calls	Seconds	Nº Calls	Seconds	Nº Calls	Seconds
Air Attack Boss-Fire Boss	3	181	4	240		
Air Attack Boss-Line Boss	16	1140	3	315		
Air Attack Boss-Helicopter Boss			11	437	2	53
Helicopter Boss-Line Boss					3	503
Helicopter Boss-Division Boss					3	295
Helicopter Boss-Portable			4	174	7	191
Air Attack Boss, Line Boss Fire Camp	7	57	5	222	2	95
Helicopter Boss-Fire Camp			5	207	1	30
Air Attack Boss-Heliport			8	189		
Helicopter Boss-Heliport			11	340	1	90
Other	2	170	9	217		
Totals	28	1548	61	2341	19	1257

*Total Monitored time: 2.77 hours
** " " " : 2.16 hours
*** " " " : 2.67 hours

Table A8. Measurements of Air Attack Communications Traffic from Lead Plane Tapes
Safety Harbor Fire, Wenatchee N.F. 7/18/70. Start: 5:30 AM

Inter-val	Tanker	Nº Iden-tifiable Calls	All Communications Traffic: Cumulative Duration (sec.)	Duration Interval (sec.)	Busy & Preempted* Time (sec.)	Pct. of Duration Interval	Tanker---Lead Plane: Tot. Tanker Contact** Time (sec.)	Pct. Busy Time	To First Drop	Subse-quent Drops	Nº Calls/ Nº & Type of Drop
0		4	283	283	245	87					
1	42	8	360	360	328	91	210	64	198		4/1
2	74	5	1065	705	525	74	277	53	375		4/1
3	42	5	1748	683	460	67	422	88	342	177	3/3
4		1	2061	313	208	66					
5	26	7	3211	1150	1037	90	937	90	334	540	4/5
6		9	4711	1500	910	61					
7	40	6	5131	420	320	76	180	56	177		4/1 Salvo
8		1	5236	105	105	100					
9	22	6	5536	300	250	83	165	66	147		3/1 Salvo
10	10	7	5941	405	270	67	180	67	162		4/1
11		18	7941	2000	1385	69					
12	14	2	8034	93	72	73	57	57	49		2/1 Salvo
13		2	8319	285	199	70					
14	26	4	8979	660	525	79	555	84	203	319	4/3

*Short idle periods not usable for other traffic. ** Including first contact time

Table A8 .(cont)

Inter-val	Air Attack Boss--Lead Plane Tot. Lgth. (seconds)	% Busy Time	№ of Calls	Air Attack Boss--Helicopter Tot. Lgth. (seconds)	% Busy Time	№ of Calls	Air Attack Boss--Line Tot. Lgth. (seconds)	% Busy Time	№ of Calls	Air Attack Boss--Airport Tot. Lgth. (seconds)	% Busy Time	№ of Calls
0	207	84	3	12	5	1						
1	79	24	3	15	5	1						
2	42	8	2				87	17	2			
3	38	8	2									
4	207	99.5	1									
5	90	9	3									
6	188	21	3	188	21	1	79	9	2	135	15	1
7				72	23	1						
8												
9	35	14	2									
10	30	11	1									
11	417	30	7	42	3	2				102	7	2
12												
13										94	47	1
14												

Table A8. (cont)

	Helicopter--Line			Helicopter--Heliport Helispot			Other Calls				
Inter-val	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Between	
0											
1											
2											
3											
4											
5											
6											
7							19	6	1	LP	A/P
8							60	57	1	AAB	G
9							19	8	1	Heli.	G
10							4	2	1	A/P	G
							15	6	1	AAB	G
11							195	14	3	AAB	G
12							147	11	2	LP	A/P

Table A8. (cont.)

	Helicopter-Line			Heliport Helicopter-Helispot			Other Calls				
Inter-val	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Between	
12(cont)							30	2	2	Air	Air
13							94	47	o	AA	G

Table A9. Measurements of Air Attack Communications Traffic from Lead Plane Tapes
Safety Harbor Fire, Wenatchee N.F. 7/18/70. Start: 10:30

			All Communications Traffic				Tanker----Lead Plane				
Inter-val	Tanker	Nº Iden-tifiable Calls	Cumulative Duration	Duration Interval (sec.)	Busy & Preempted* Time (sec.)	Pct. of Duration Interval	Tot. Tanker Contact** Time (sec.)	Pct. Busy Time	To First Drop	Subse-quent Drops	Nº Calls/ Nº & Type of Drop
1	42	7	532	532	445	84	400	90	85	315	4/3
2	41	3	887	355	325	58	110	54	85	25	2/2
3		1	1137	250	210	84	0				
4	74	5	1597	460	118	26	65	55			3/1
5		7	2582	985	335	34	0				
6	26	4	3732	1150	1060	92	925	87	285	640	3/3 1000 gal.
7	40	3	4112	380	260	69	230	88	208	0	2/1 Salvo
8		2	5252	1140	95	8	0				
9	74	1	5657	405	320	79	320	100	280		1/1 Salvo
10		6	6437	780	244	31	0				
11	42	3	6817	380	190	67	175	92			2/0
12		4	7567	750	205	27	0				
13	26	12	9367	1800	1370	76	935	68	280	655	5/3 1000 gal.
14	40	3	9712	345	188	55	23	12			1/0
15	74	3	10492	780	425	55	425	100	380		3/1 Salvo
16	40	5	11082	590	214	36	85	40	70		2/1
17	10	2	11347	265	54	21	22	41			1/1

*Short idle periods unusable for other traffic.

** Including first contact time

Table A9 · (cont.)

Inter-val	Air Attack Boss--Lead Plane Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Air Attack Boss--Helicopter Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Air Attack Boss--Line Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Slurry Base Air Attack Boss--Airport Dispatcher Tot. Lgth. (seconds)	% Busy Time	Nº of Calls
1	20	5	1	15	3	1	0			0		
2	0			0			0			0		
3	210	100	1	0			0			0		
4	35	30	1	0			0			0		
5	0			157	47	4	0			0		
6	0			0			0			0		
7	0			30			0			0		
8	0			0			35	37	1(LB)	0		
9	0			0			0			0		
10	0			0			0			0		
11	0			0			0			0		
12	0			60	29	1	0			0		
13	0			0			0			0		
14	0			125	66	1	0			0		
15	0			0			0			0		
16	102	48	2	0			0			0		
17	0			0			32	59	1(LB)	0		
										0		

Table A9. (cont.)

	Helicopter--Line			Helicopter--Heliport Helispot			Other Calls				
Inter-val	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Calls Between	
1											
2							20	10	1	AAB	Okanagdan
3											
4							15	13	1	LP	LB
5							120	36	3	Ground	AAB
6							90	9	1	LP	LB
7											
8							60	63	1	LP	LB
9											
10							87	36	3	LP	H
							127	52	2	LP	LB
							30	12	1	443,28	ETA Yacoma
11							15	8	1	LP	LB
12							85	41	1	LP	443

Table A9. (cont.)

Inter-val	Helicopter-Line Tot. Lgth. (seconds)	Helicopter-Line % Busy Time	Helicopter-Line Nº of Calls	Heliport Helicopter-Helispot Tot. Lgth. (seconds)	Heliport Helicopter-Helispot % Busy Time	Heliport Helicopter-Helispot Nº of Calls	Other Calls Tot. Lgth. (seconds)	Other Calls % Busy Time	Other Calls Nº of Calls	Calls Between	
12(cont)							15	7	1	LP	LB
							45	22	1	LB	FB
13							45	3	1	AAB	Okangdan
							50	4	1	B	
							215	16	3	LP	LB
							130	22	2	B40	
14							47	25	1	LP	LB
15											
16							27	13	1	B10	
17											

Table A10. Measurements of Air Attack Communications Traffic from Lead Plane Tapes

Pumpkin Fire, Bighorn N. F., 8/19/70. Start: 6:30 a.m.

			All Communications Traffic				Tanker----Lead Plane				
Inter-val	Tanker	Nº Iden-tifiable Calls	Cumulative Duration (sec.)	Duration Interval (sec.)	Busy & Preempted* Time (sec.)	Pct. of Duration Interval	Tot. Tanker Contact ** Time(sec.)	Pct. Busy Time	To First Drop	Subse-quent Drops	Nº Calls/ Nº & Type of Drop
1	14	6	360	360	260	72	200	77	195		3/1 Salvo
2	18	6	690	330	316	96	232	73	176		3/1
3		2	870	180	140	78	0				2/1
4	19	3	1155	285	225	79	165	73	147		2/1
5	15	4	1480	325	280	86	216	77	192		3/1 Salvo
6		15	2400	920	620	67	0				
7	25	9	2996	596	503	84	390	77	383		3/1
8	17	10	3408	412	352	85	214	61	207		4/1 Salvo
9		3	3508	100	64	64	0				
10	23	7	4040	532	460	86	410	89	293	98	4/2
11			4112	72	0	0	0				
12	18	4	4314	202	142	70	139	98	135		3/1
13		3	4456	142	132	93	128	97	113		2/1
14		3	4591	135	93	69	0				

Table A10.(cont.)

Inter-val	Tanker	Nº Iden-tifiable Calls	All Communications Traffic: Cumulative Duration (sec.)	Duration Interval (sec.)	Busy & Preempted* Time (sec.)	Pct. of Duration Interval	Tot. Tanker Contact** Time (sec.)	Tanker - Lead Plane: Pct. Busy Time	To First Drop	Subse-quent Drops	Nº Calls/ Nº & Type of Drop
15	19	5	4801	210	180	86	84	47	49		3/1
16		3	4941	140	115	82	0				
17	15	4	5221	280	235	84	165	70	162		2/1
18		10	5681	460	360	78	0				
19	25	11	6046	365	235	64	186	79	109	147	6/2
20	17	10	6476	430	310	72	263	85	113	139	6/2
21		2	6721	245	60	21	0				
22	5	7	7126	405	230	57	15	7			
23	18	2	7306	180	150	84	140	93	117		1/1
24	14	5	7461	155	110	72	85	77	64		
25		0	7561	100	0	0	0				
26		2	7839	278	113	40	0				
27	19	1	7959	120	120	100	120	100	109		1/1
28		10	8244	285	140	49	0				
29	14	8	8659	415	350	84	229	65	207		4/1
30		8	8939	280	171	61	0				

*Short idle periods unusable for other traffic. ** Including first contact time

Table A10.(cont.)

	Air Attack Boss--Lead Plane			Air Attack Boss--Helicopter			Air Attack Boss--Line			Air Attack Boss--Airport Slurry Base Dispatcher		
Inter-val	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconsd)	%Busy Time	Nº of Calls
1												
2												
3	117	84	1									
4	4	2	1									
5												
6	297	48	6	30	5	1						
7	8	2	1									
8	8	2	1	5	1	1						
9	19	30	1									
10	12	3	1	49	11	2						
11												
12	8	6	1									
13												
14	45	48	1									
15				46	26	1						

Table A10. (cont.)

	Air Attack Boss-Lead Plane			Air Attack Boss-Helic.			Air Attack Boss-Line			Airport Air Attack B.-Slurry B. Dispatcher		
Inter-val	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Tot. Lgth. (seconds)	% Busy Time	Nº of Calls
16	30	26	1	83	72	2						
17	4	2	1									
18	123	34	3	64	18	2	123	34	3			
19	12	5	1				23	10	1			
20												
21				34	57	1						
22	38	17	1	30	13	1	117	51	1			
23				12	8	1						
24												
25												
26	113	100	2									
27												
28	68	49	5	64	46	3						
29												
30	53	31	2	120	70	4						

Table A10. (cont.)

Interval	Helicopter---Line: Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Helicopter--Heliport Helispot: Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Other Calls: Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Calls Between	
1							23	9	1	F.C.	Air
2							23	7	1	F.C.	LP
							53	17	2	Air	G
3							23	16	1		AAB
4											
5							60	21	2	Heli.	LP
6				19	3	1	30	5	1	AP	LP
							27	4	1	Heli.	LP
7							75	15	1	LP	B17
							4	1	1	LP	A/P
							4	1	1	Heli.	LP
8							23	7	1	Slurry	LP
							23	7	2	Heli.	LP
9							4	6	1	Heli.	LP
10											
11											

Table A10. (cont.)

Inter-val	Helicopter - Line: Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Helicopter - Heliport Helispot: Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Other Calls: Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Calls Between	
12											
13							4	3	1	LP	B18
14											
15											
16											
17											
18							38	11	1	Cody Slurry	Baker Base
19											
20							30	10	1	Heli.	G
21											
22							15	7	2	LP	Tanker
23											
24											
25											
26											
27											
28											
29							38	11	3	Heli.	LP

Table A10 (cont.)

Inter-val	Helicopter-Line Tot. Lgth. (seconds)	% Busy Time	№ of Calls	Heliport Helicopter-Helispot Tot. Lgth. (seconds)	% Busy Time	№ of Calls	Other Calls Tot. Lgth. (seconds)	% Busy Time	№ of Calls	Calls Between	
30							38	22	1	Air	Air
							34	20	1	Heli.	LP

Table A11. Measurements of Air Attack Communications Traffic from Lead Plane Tapes
Slide Ridge Fire, Wenatchee N.F. 8/27/70.

			All Communications Traffic				Tanker⟷Lead Plane				
Inter-val	Tanker	№ Iden-tifiable Calls	Cumulative Duration (sec.)	Duration Interval (sec.)	Busy & Preempted* Time (sec.)	Pct. of Duration Interval	Tot. Tanker Contact** Time (sec.)	Pct. Busy time	To First Drop	Subse-quent Drops	№ Calls/ № & Type of Drop
1	26	8	740	740	460	62	450	98	435		7/1
2	64	3	1264	524	489	93	487	100	172	318	3/2
3	71	9	2936	1672	1242	74	30	2			1/
4	11	7	3816	880	860	98	325	38	305	20	3/2
5	71	3	4333	517	517	100	220	43	205		1/1
6	64	3	4663	330	235	71	265	113	260		1/1
7	26	8	5133	470	364	77	271	75	256		4/1
8	16	1	5433	300	160	53	247	154	232		1/1
9	26	1	5688	255	110	43	200	182	180		1/1
10		5	6408	720	565	79					
11	71	8	7648	1240	930	75	692	74	322	370	3/2
12	11	1	8228	580	430	74	565	131	430	135	1/2
13	16	2	8595	367	282	77	262	93	232		1/1
14	26	7	9455	860	630	73	222	35	200		2/1

*Short idle periods unusable for other traffic.
**Including first contact time

Table A11. (cont)

Inter-val	Air Attack Boss↔Lead Plane Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Air Attack Boss↔Helicopter Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Air Attack Boss↔Ground Tot. Lgth. (seconds)	% Busy Time	Nº of Calls	Air Attack Boss↔Fire Boss Tot. Lgth. (seconds)	% Busy Time	Nº of Calls
1												
2												
3	70	5.6	1				115	9.3	2			
4												
5	65	12.6	1									
6												
7	105	28.8	4									
8												
9												
10	80	14.2	1				103	18.2	2	40	7.1	1
11	128	13.8	2									
12												
13	90	31.9	1									
14	165	26.2	3									

Table A11. (cont.)

Inter-val	Lead Plane--Heliport Tot. Lgth. (seconds)	Lead Plane--Heliport % Busy Time	Lead Plane--Heliport Nº of Calls	Lead Plane--Ground Tot. Lgth. (seconds)	Lead Plane--Ground % Busy Time	Lead Plane--Ground Nº of Calls	Other Calls Tot. Lgth. (seconds)	Other Calls % Busy Time	Other Calls Nº of Calls	Calls Between	
1							10	2.2	1	LP	B64
2							20	4.1	1	LP	B26
3				40	3.2	1	25	2.0	1	LP	B64
							20	1.6	1	AA	B64
							85	6.9	2	LP	Miler
4	45	5.2	1				17	2.0	2	LB	DB
							10	1.2	1	B11	G
5				60	11.6	1					
6				22	9.4	1					
7											
8											
9											
10				10	1.8	1					
11	60	6.5	2	25	2.7	1					
12											
13											
14				50	7.9	1	115	18.3	1	LP56Z	LP16Z

Table A12. Number of days with one or more fires size class E and larger (each lasting longer than one day) on listed sample forests during the worst four months in each region (or area) for 1960 - 1970.

Forest	Simultaneous Fires E and Larger										
	1	2	3	4	5	6	7	8	9	10	>10
Nezperce	20	13	0	0	0	0	0	0	0	0	0
Bitterroot	26	5	0	0	0	0	0	0	0	0	0
Clearwater	5	15	7	0	0	0	0	0	0	0	0
St. Joe	0	0	0	0	0	0	0	0	0	0	0
R-1 Total	51	33	7	0	0	0	0	0	0	0	0
Payette	17	3	0	0	0	0	0	0	0	0	0
Boise	18	0	0	0	0	0	0	0	0	0	0
Salmon	21	0	0	0	0	0	0	0	0	0	0
Sawtooth	10	0	0	0	0	0	0	0	0	0	0
R-4 Total	66	3	0	0	0	0	0	0	0	0	0
Los Padres	13	0	0	0	0	0	0	0	0	0	0
Angeles	6	7	3	0	3	0	0	0	0	0	0
San Bernardino	15	8	0	0	0	0	0	0	0	0	0
Cleveland	8	2	2	0	0	0	0	0	0	0	0
R-5 Total	42	17	5	0	3	0	0	0	0	0	0
Umatilla	0	5	4	6	0	1	0	0	0	0	0
Wallowa-Whitman	0	6	0	2	0	1	0	0	1	1	0
Gifford Pinchot	0	0	0	0	0	0	0	0	0	0	0
Snoqualmie	0	0	0	0	0	0	0	0	0	0	0
Wenatchee	22	3	0	1	1	1	5	0	0	0	0
Okanogan	2	1	4	4	0	0	0	0	0	0	0
R-6 Total	24	15	8	13	1	3	5	0	1	1	0
Grand Total(298)	183	68	20	13	4	3	5	0	1	1	0

Table A13. Summaries of link requirements from questionnaire responses; expressed in percenatge of respondents replying affirmatively and grouped by essential or important need.

I. CRASH BOSS

A. From Thirty Crew Boss Replies:

Link 1/ Crew Boss to:	Percenatge "Yes" Essential	Percenatge "Yes" Important
Own Sector Boss	80	20
His Squad Bosses	73	10
Safety Lookout	57	7
Crew Bosses in own + Adj. Sectors	27	30
His Division Boss	27	23
All Crew Bosses in Sector	27	17
Firing Boss	17	17
Tractor Boss	17	17
Pumper Boss	7	27
Line Scout	20	13
Falling Boss	20	13
Helicopters	20	10
Downhill Crew	30	-
Own + Adj. Sector Bosses	17	13

B. From Thirty-One Sector Boss Replies:

Link 2/ Crew Boss to:	Percenatge "Yes" Essential	Percenatge "Yes" Important
Own Sector Boss Only	42	10
Safety Lookout	35	16
All Crew Bosses in Sector	32	19
Own + Adj. Sector Bosses	10	29
Own Squad Bosses	23	10
Falling Boss	10	16
Pump Relay Points	6	19
Firing Boss	6	19

1/ Links required by less than 30% of respondents not shown.
2/ Links required by less than 25% of respondents not shown.

Table A13. (cont.)

II. SECTOR BOSS

A. From Thirty-Two Sector Boss Replies:

Link 1/ Sector Boss to:	Percenatge "Yes" Essential	Important
Own Division Boss	94	-
All Crew Bosses in Sector	85	3
Adj. Sector Bosses	58	12
Safety Lookout	45	3
Line Scout	39	9
Falling Boss	39	9
Tractor Boss	36	15
Pumper Boss	36	9
Firing Boss	33	12
All Sector Bosses in Division	33	9
Crew Bosses in Own + Adj. Sectors	24	15
Air Attack Boss	24	6
Helicopters	21	15
Line Boss	21	12
Lead Plane	21	9
Div. + Adj. Div. Bosses	12	21
Tanker Boss	30	12

B. From Twenty-Four Division Boss Replies:

Link 2/ Sector Boss to:	Percentage "Yes" Essential	Important
Own Division Boss	88	8
Own Crew Bosses	67	4
Firing Boss	79	-
Safety Lookout	54	25
Falling Boss	58	21
All Sector Bosses in Division	50	25
Line Scout	50	25
Tractor Boss	67	8
Tanker Boss	58	13
Pumper Boss	50	8
Adjoining Sector Bosses	21	17
Division Boss + Adj. Div. Bosses	4	33
Downhill Crew	29	8
Helicopters	21	17
Air Attack Boss	13	17
Lead Plane	8	17

1/ Links required by less than 30% of respondents not shown.
2/ Links required by less than 25% of respondents not shown.

Table A14. **Fire Occurrences (class C and larger) For Sample Forests in Region 6 (area B1); Four High Fire Months.**
Wallowa-Whitman, Umatilla

Days of the Month

Month/ Year	Fire Class	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
July 1960	C									1						1		1		3	12	3	1				1	1	1			
	D																	1		2	10	6	5	3	2	1	1					
	E																			2	4	2	1	1	1	1						
	F																			2	7	6	4	2	1	1	1	1	1	1	1	1
	G																			4	5	5	5	5	4	4	4	4	4	4	1	1
Total	7/60									1						1		2		13	38	22	16	11	8	7	7	6	6	5	2	2
July 1961	C	1																											1	1		
	D															1																
	E														2	1	1															
	F														1																	
	G														1	1	1															
Total	7/61	1													4	3	2												1	1		
Aug. 1961	C			1	1				1						1				1				1									
	D			2	1	1	1			1								1	1				2									
	E									1																						
	F																															
	G																															
Total	8/61			3	2	1	1		1	2					1			1	2				3									
Aug. 1966	C						1				1										1											
	D	1	1																2													
	E																															
	F																															
	G																															
Total	8/66	1	1				1				1								2		1											

Table A15. Fire Occurrences (class C and larger)
For Sample Forests in Region 6, (area B3); Four High Fire Months.
Wenatchee, Gifford-Pinchot, Okanogan, Snoqualmie

Days of the Month

Month/ Year	Fire Class	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Aug. 1961	C								1						1	2	2						1		1	1					1	
	D																1															
	E											1											1									
	F																															
	G																															
Total	8/61								1			1			1	2	3						2		1	1					1	
Aug. 1968	C	1	1	1	1																											
	D																															
	E																															
	F					1	1	1																								
	G				1	1	1	1	1	1	1	1																				
Total	8/68	1	1	1	2	2	2	2	1	1	1	1																				
July 1970	C																6	7	6	6	6		1									
	D																5	5	4	4	1	1	1									
	E																1	1	1	2	2	2	1	1	1							
	F																1	1	2	1	1	1	1	1	1	1	1					
	G																1	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
Total	7/70																14	16	15	15	12	6	6	4	3	2	2	1	1	1	1	1
Aug. 1970	C																							4	10	9	8	6	6	5	4	3
	D																							1	4	4	4	4	4	4	3	2
	E																							1	2	2	2	2	2	1	1	
	F																								2	2	2	2	2	2	1	1
	G																								3	3	3	3	3	3	3	3
Total	8/70																							6	21	20	19	17	17	15	12	9

Table A16. Fire Occurrences (class C and larger)
For Sample Forests in Region 5; Four High Fire Months. (Area B2)
Los Padres, Angeles, San Bernardino, Cleveland

Days of the Month

Month/ Year	Fire Class	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	C								1											1	1	1		1	1							
July	D										1				1		1							1								
1960	E														1						1	1	1	1			1	1	1	1		
	F																				2	3	3	3	1							
	G																	1	1	2	3	4	4	4	4	3	3	2	2	1		
Total	7/60								1		1				2		1	1	1	3	7	9	8	10	6	3	4	3	3	2		
	C											1	1					1				2							2			
June	D																															
1966	E												1																	1		
	F																															
	G												1	1	1	1	1	1	1	1	1	2	2	1								
Total	6/66											1	3	1	1	1	1	2	1	1	1	4	2	1					2	1		
	C				1			1							1	1												1	1	1		
Sept.	D														1																	
1970	E																									1		1				
	F						1	1	1																		1	3	2	2	1	
	G						1	1	1																	1	1	3	4	4	4	
Total	9/70				1		2	3	2						2	1										2	2	8	7	7	5	
	C																					1										
Nov.	D																															
1970	E																															
	F												1	1	1	1	1	1	1	1	1	1										
	G													1	1	1	1	1	1	1	1											
Total	11/70												1	2	2	2	2	2	2	2	2	2										

Table A17. Fire Occurrences (class C and larger)
For Sample Forests in Region 4; Four High Fire Months. (Area B1)
Payette, Boise, Salmon, Sawtooth

Days of the Month

Month/ Year	Fire Class	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
July 1960	C						1	1		1			1	1	2	2	1	1	1		1	2	1	3	2		1					
	D																1	2		1							1					
	E										1				1						1											
	F													1	1	1								1	1	1	1					
	G													1	1	1	1			1	2	2	1	1	1	1	1	1	1			
Total	7/60						1	1		1	1		1	3	5	4	3	3	1	2	4	4	2	5	4	2	4	1	1			
July 1961	C								3	3	2	1																				
	D		1																													
	E																	1		2	2	2		1	1	1	1	1	1	1	1	
	F																							1	1	1						
	G																															
Total	7/61		1						3	3	2	1						1		2	2	2		2	2	2	1	1	1	1	1	
Aug. 1961	C			2	2					1			1	1		1	3	3	2										2	1		
	D																															
	E			1	1	1										1																
	F			1	1	1	1	2	1								1	1	1	1	1											
	G																															
Total	8/61			4	4	2	1	2	1	1			1	1		2	4	4	3	1	1								2	1		
Aug. 1966	C			1	2	4	3	1																		1	1	1	1	1		
	D				1	1																				1						
	E				1																											
	F																															
	G				1	1	1	1	1	1	1															1	1	1	1			
Total	8/66			1	5	6	4	2	1	1	1															3	2	2	2	1		

Table A18. **Fire Occurrences (class C and larger)**
For Sample Forests in Region 1; Four High Fire Months. (Area B1)
Nezperce, Clearwater, Bitterroot, St. Joe

Days of the Month

Month/ Year	Fire Class	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
July 1960	C											1	1		1	2	1	1		1	1	1	1					1	1			
	D												1	1	1					1	1	1										
	E										1	1																				
	F																			1	2	2	2	2	1	1	1					
	G																			1	1	1	1	1	1	1	1	1				
Total	7/60										1	2	2	1	2	2	1	1		4	5	5	4	3	2	2	2	2	1			
July 1961	C					1	1	1	1	1	1	1	1	1	1	1	1	1	1									1				
	D															1	1	1														
	E																															2
	F																															
	G																								1	1	1	1	1	1	1	1
Total	7/61					1	1	1	1	1	1	1	1	1	1	2	2	2	1						1	1	1	2	1	1	1	3
Aug. 1961	C				4	4	4	2	2	1	1					3	3	3	2	2	2	2	2	2	4	4	3	3	1			
	D															1	1	1														
	E	2	1													2	2	2	2	2	2	2	1		1	1	1	1	1	2	1	1
	F					3	3	3	3	3	3	2	2	2	2	3	3	3	3	3	3	3	3	3	1							
	G	1	1	1	2	3	3	3	3	3	3	3	2	2	1	1	1	1	1	1												
Total	8/61	3	2	1	6	10	10	8	8	7	7	5	4	4	3	10	10	10	8	8	7	7	6	5	6	5	4	4	2	2	1	1
Aug. 1966	C					1	1																			1	1	1				
	D	1	1																													
	E																															
	F																															
	G																															
Total	8/66	1	1			1	1																			1	1	1				

Table A19. Fire Occurrences (class C and larger) For Sample Forests in Regions 1,4 and 6 (area B1); Four High Fire Months.

Nezperce, Clearwater, Bitterroot, St. Joe, Payette, Boise, Salmon, Wallowa-Whitman, Umatilla, Sawtooth

Days of the Month

Month/ Year	Fire Class	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
July 1960	C						1	1		2		1	2	1	3	5	2	3	1	4	14	6	3	3	2		1	1	2			
	D													1	1		1	3		4	11	7	5	3	2	1	1					
	E										2	1	1		1					2	5	2	1	1	1	1						
	F													1	1	1				3	9	8	6	5	3	3	3	1	1	1	1	1
	G													1	1	1	1			6	8	8	7	7	6	6	6	6	6	4	1	1
Total	7/60						1	1		2	2	2	3	4	7	7	4	6	1	19	47	31	22	19	14	11	11	8	9	5	2	2
July 1961	C	1				1	1	1	4	4	3	2	1	1	1	1	1	1	1									1	1	1		
	D		1													2	1	1														
	E														2	1	1	1		2	2	2		1	1	1	1	1	1	1	1	2
	F														1									1	1	1						
	G														1	1	1								1	1	1	1	1	1	1	1
Total	7/61	1	1			1	1	1	4	4	3	2	1	1	5	5	4	3	1	2	2	2		2	3	3	2	3	3	3	2	3
Aug. 1961	C			3	7	4	4	2	3	2	1		1	1	1	4	6	6	5	2	2	2	3	2	4	4	3	3	3	1		
	D			2	1	1	1				1					1	1	2	1				2									
	E	2	1	1	1	1					1					3	2	2	2	2	2	2	1		1	1	1	1	1	2	1	1
	F			1	1	4	4	5	4	3	3	2	2	2	2	3	4	4	4	4	4	3	3	3	1							
	G	1	1	1	2	3	3	3	3	3	3	3	2	2	1	1	1	1	1	1												
Total	8/61	3	2	8	12	13	12	10	10	8	9	5	5	5	4	12	14	15	13	9	8	7	9	5	6	5	4	4	4	3	1	1
Aug. 1966	C			1	2	5	5	1				1									1		1			2	2	2	1	1		
	D	2	2		1	1													2				2			1						
	E				1																											
	F																															
	G				1	1	1	1	1	1	1															1	1	1	1			
Total	8/66	2	2	1	5	7	6	2	1	1	1	1							2		1		3			4	3	3	2	1		

Exhibit B1. Sample large fire questionnaire.

LARGE FIRE TELECOMMUNICATION REQUIREMENTS QUESTIONNAIRE*

Please base ALL your answers in this questionnaire on your fire job experiences and needs as FIRE BOSS.

When and where did you last serve in this position? June 1968, Los Padres ~~Rattlesnake Fire~~

Your most recent large fire experience was in Region 5 on the Los Padres National Forest in 1968 (year). The name of the fire was Rattlesnake and your fire job was Fire Boss

Served on more than 100 Large Fires between 1951 & 1968, in Regions 5, 3 & 4. GHQ Fire Boss on the Coyote ('64) & Wellman ('66) Fires - R-5.

Complete this at your option:

Name: (Deleted by study team for reproduction.)

Title:

Location:

* Large Fire is defined as multi-division or serious multi-fire situations. Telecommunications is the sending and receiving of messages with artificial aids at a distance.

CONTACTS	Total est. number calls per shift	NATURE OF NEEDED COMMUNICATION LINKS					
		ESSENTIAL (To your job performance or safety)			IMPORTANT (To your effective job performance or safety)		CONVENIENT (Increases job effectiveness)
		Can tolerate practically no delay in placing most (90%) calls to this party	Can tolerate some delay in placing most calls to this party	Delay time is not a factor	Can tolerate some delay in placing most calls to this party	Delay is not a factor	Delay is not a factor
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ll Crew Bosses							
ll Crew Bosses n Division							
ll Crew Bosses n Sector							
rew Bosses on our & adjoining ectors							
our Crew Boss							
ll Squad Bosses							
ll Squad Bosses n Division							
quad Bosses on our & adjoin- ng Sectors							
our quad Bosses							
ead Plane	6	✓					
ir Tankers	2		✓				
elicopters	4	✓					
ump Plane							
econn. Plane							
argo Plane							
ir Dispatcher							
lurry Base							
ine Scout							
alling Boss							

ontinued on next page

1. State your communication requirements, for the fire job shown on the top of the title page, during a busy shift before containment. Assuming all contacts listed below are possible, show your requirements whether or not such communication links presently exist and whether or not the need is an essential one or belongs to one of the other two categories. For each contact (i.e., line in the table):

   a. Enter in Column 1 the appropriate number of calls you expect to initiate during a busy shift for a given contact.

   b. Place a check in one of the Columns 2 through 7 that best fits the nature of your calls to the particular contact.

		NATURE OF NEEDED COMMUNICATION LINKS					
		ESSENTIAL (To your job performance or safety)			IMPORTANT (To your effective job performance or safety)		CONVENIENT (Increases job effectiveness)
CONTACTS	Total est. number calls per shift (1)	Can tolerate practically no delay in placing most (90%) calls to this party (2)	Can tolerate some delay in placing most calls to this party (3)	Delay time is not a factor (4)	Can tolerate some delay in placing most calls to this party (5)	Delay is not a factor (6)	Delay is not a factor (7)
Fire Boss							
Line Boss	10	✓					
Air Attack Boss	6	✓					
All Div. Bosses	4	✓			WACO		
Div. & Adjoining Div. Bosses							
Specific ~~Your~~ Div. Boss	2	✓					
All Sec. Bosses							
All Sec. Bosses in Div.							
Sec. & Adjoining Sec. Bosses							
Specific ~~Your~~ Sec. Boss	2	✓					

Continued on next page

CONTACTS	Total est. number calls per shift (1)	NATURE OF NEEDED COMMUNICATION LINKS: ESSENTIAL (To your job performance or safety): Can tolerate practically no delay in placing most (90%) calls to this party (2)	Can tolerate some delay in placing most calls to this party (3)	Delay time is not a factor (4)	IMPORTANT (To your effective job performance or safety): Can tolerate some delay in placing most calls to this party (5)	Delay is not a factor (6)	CONVENIENT (Increases job effectiveness): Delay is not a factor (7)
anker Boss							
ractor Boss							
umper Boss							
iring Boss							
afety Lookout							
ump Relay oints							
own Hill Crew							
FHQ	5	✓					
ire Camp	10	✓					
eliport	5	✓					
elispot	5		✓				
ispatcher	10		✓				
ir Service Mgr	1		✓				
ookouts	2	✓					
ther:							
istrict Office	4				✓		
rest Supv.	2				✓		
	Σ 80						

These are probably conservative figures & ~~there~~ may be ~~others that~~ are equally essential.

Questions 2 through 7 refer to preceding table:

2. For those contacts with checks in Column 2, give the reasons for this requirement and the circumstances when the requirement becomes essential.

Contacts	Reasons and when Essential
All	Overall mgt. of Fire forces & checking on specific situations, both on line & in Service & Pl

3. For contacts checked in Column 3, the delay should not exceed about 5 minutes for most (about 90%) calls.

4. For contacts checked in Column 5, the delay should not exceed about 10 minutes for most (about 90%) calls.

5. For contacts listed as convenient, in Column 7, how does the contact improve your job effectiveness? NA

6. List your contacts in Question No. 1 that you believe must be direct, without verbal relay. (Write None, if none must be direct.) Most (about

Line Boss, Air Attack Boss, Specific Div. & Sector Bosses, Lead Plane, Air Tankers, Helicopters, GHQ & Fire Camp, ~~[illegible]~~ Dispatcher

7. From your listed contacts in Question No. 1, note the contacts that you frequently can't reach, or can reach only with great difficulty, and give your ideas why (no radio, different frequency, topography, garbled relays, congested channel, etc.).

Contact	Reason you can't reach
Line Boss & Div. Boss	Topography & busy air
Fire Camp & GHQ	Busy air & phones
Dispatcher	" " "
Air Attack Boss, Lead Plane, Air Tanker & Helicopter	Limited Air Net & busy air

Questions 8 through 25 should be answered in the light of large fire experiences for the position shown in the first sentence of the title page.

8. What separate telecommunications equipment do you usually have available to you?

[ ] Personal portable	[ ] Line Net	[ ] Telephone
[x] Portable	[x] Air Net	[ ] Radio Telephone
[x] Mobile	[x] Forest Net	[ ] Other
[ ] Stationary unit	[ ] Intra-sector Net	
	[ ] Other________	
	[ ] Don't know	

9. How would you characterize your above large fire telecommunication facilities?

   [ ] Very satisfactory

   [ ] Satisfactory

   [x] Just passable for about 50% of Fires

   [x] Unsatisfactory other 50% of Fires in back country

   If you checked "unsatisfactory", state why:
   For the 50% of fires occurring in "back country", there just isn't enough of a "backbone" system. Not enough "links", "repeaters" or channels. Need minimum of Air, Fire, Forest Admin. & Service channels

10. Circle your primary large fire communication network:

   Air Net   Line Net   Forest Net   Intra-sector Net   Other________

11. Circle number which most nearly represents your feeling about the degree of congestion on your primary telecommunications network during a busy shift on a large fire:

   Out of every ten calls you make, or think of making, the number of calls delayed because you hear someone talking on the channel is:

   0   1   2   3   4   5   6   7   8   9   10

11a. Circle your estimate of the period of time in hours during which you initiate ten calls on a busy shift:

   1/2   1   2   3   4   5   6   7   8   10   12 or more

11b. Estimate the number of calls you receive per hour over your primary network during a busy shift: 5.

12. Circle the number which most nearly represents the calls you decide not to bother making because your primary telecommunication network is busy:

Out of every 10 calls you want to make: None Fewer than one

1 2 3 4 5 more than 5 calls will not be made because

of network congestion.

13. Which statement describes your actions best when you want to make a call and the line is busy?

You monitor the radio traffic over your channel continuously in order to get on immediately after the channel clears in

- [ ] No instance
- [ ] A few instances (fewer than one-quarter)
- [ ] A moderate number of instances (about one-quarter)
- [ ] About one-half of the cases
- [ ] About three-quarter of the cases
- [x] Most of the cases (about nine-tenths)
- [ ] Always

14. When you wish to place a call and find the channel busy, and you don't monitor the channel continuously, your actions are best described by:

- [ ] I monitor intermittently for a period of (about) ____ minutes and then stop and try again later (in about ____ minutes).
- [ ] I forget it immediately and try later (in about ____ minutes)
- [x] Other (please describe) If it is urgent, I try an alternate net or relay, or even send messenger.

15. Which are usually the busiest hours for communications on your job considering a typical busy shift:

Day Shift: Hours from 6A to 10A and from 2P to 6P

Night Shift: Hours from 6P to 9P and from 4A to 6A

16. What, in your opinion, is the single most important improvement in telecommunications equipment or telecommunications management that will help you do your listed fire job? Reliable, compatible, multi-channel equipment functioning within a well designed system with adequate links & repeaters - (micro-wave).

17. What other improvements in telecommunications do you consider desirable? Remote systems for monitoring weather data, etc. (reasonable cost) to achieve automatic weather stations. Radio discipline & enforcement.

18. Please give the reasons underlying your recommendations for improvements and state what benefits in safety, resource conservation, materials and manpower utilization, improved effectiveness or other benefits would be likely from these improvements. It would be impossible to fight a military battle without adequate communications - it is difficult to fight a fire for many of the same reasons.

19. Do good radio communications contribute to more rapid control activities or greater productivity?

[✓] Yes [ ] No

If your answer is yes to the above question, give your evaluation of the time saved on your main tasks or your assessment of the productivity increases (i.e., amount of time saved in building line on line segment, earlier containment time, additional length of line built, manning of longer line, wider worker spacing, etc.).

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There would be considerably less "lost motion" or wasted effort. There would be fewer "gaps" or areas not "tied in" because of inability to respond to changing situations.

20. If you use or monitor more than one piece of radio equipment on the fire line, indicate if this presents a problem and the way you cope with it: Yes, it poses a problem. If it is real busy, I have to have someone help me & monitor the nets - so that I can remain somewhat flexible.

21. Do you find it necessary to monitor your network(s) to keep informed about the general fire situation?

/✓/ Yes, I do need to monitor the Air & Fire net(s).

/_/ I like to monitor my networks, but it is not very important that I be able to do so.

/_/ No, I do not need to monitor my network.

22. If you are involved in a situation where:

a. There is a divided responsibility fire (Co-Fire Bosses)

b. You are a Cooperator (Another Agency - Fire Boss)

c. Another Agency is a Cooperator (FS Fire Boss)

Need more & better comm. & links equip.

Indicate the communication difficulties that most commonly arise in your position in these situations and what improvements in the communication system you suggest. (Use extra sheet of paper if necessary)

a. Maintaining cross communication between agencies & FB

b. Place our representative w/comm. w/cooperator.

c. Place cooperator representative w/comm. w/ F.S.

23. Do you have frequent difficulties using your communication equipment due to high noise levels around you?

/✓/ Yes /_/ No

If Yes, indicate: 1. How frequent and severe the problem; 2. What you usually do to surmount this problem; 3. What your preferred solution would be 1. About 10-20% of time - blocks out

2. Either wait until it passes (helicopter, tractor) or move to quieter location.

3. Quiet machinery (not very practical now)

24. Is it desirable for any positions immediately under your control to share their telecommunications facilities?

/✓/ Yes /_/ No

If yes, comment: As long as it doesn't restrict use in primary assignment or diminish effectiveness.

25. For those positions under your immediate control which require communication facilities, list by a check mark the communication links needed in the performance of their jobs. (Fill in job titles at head of each column.)

COMMUNICATION LINKS NEEDED

Contacts	Position 1 Job Title: Line Boss		Position 2 Job Title: Plans Chief		Position 3 Job Title: Service Chief	
	Essential Need	Important Need	Essential Need	Important Need	Essential Need	Important Need
re Boss	✓		✓		✓	
ne Boss	~~✓~~			✓		✓
r Attack Boss	✓			✓		
l Division sses	✓			✓		✓
v. Boss & Adjoining v. Bosses						
m Div. Boss Only						
l Sector Bosses						
l Sector Bosses Division						
ector Boss & Adjoin. ector Bosses						
m Sector Boss Only						
ll Crew Bosses						
ll Crew Bosses in ivision						
ll Crew Bosses Sector						
ll Crew Bosses in ec. & Adjoin. Sec.						
m Crew Boss Only						
l Squad Bosses						
l Squad Bosses Division						
l Squad Bosses in ec. & Adjoin Sec.						
m Squad Bosses						
ine Scout						
alling Boss						
anker Boss						
ractor Boss						

Continued on next page

COMMUNICATION LINKS NEEDED

Contacts	Position 1 Job Title: Line Boss — Essential Need	Position 1 Job Title: Line Boss — Important Need	Position 2 Job Title: Plans Chief — Essential Need	Position 2 Job Title: Plans Chief — Important Need	Position 3 Job Title: Service — Essential Need	Position 3 Job Title: Service — Important Need
Pumper Boss						
Firing Boss		✓				
Lookout(Safety)						
Pump Relay Points						
Down Hill Crew						
Fire Camp	✓		✓		✓	
GHQ						
Lead Plane		✓				
Air Tankers		✓				
Helicopters		✓				
Jump Plane		✓				
Reconn. Plane	✓			✓		
Cargo Plane						✓
Air Dispatcher					✓	
Slurry Base						✓
Heliport				✓	✓	
Helispot						✓
Dispatcher		✓	✓		✓	
Air Service Mgr.					✓	
Lookouts		✓				
Other:						

26. Please comment on any aspects of the large fire telecommunications situation of concern to you, not covered sufficiently in the previous questions: I can see signs of improvement already! Each "Fire" Forest needs a well designed & maintained system with modern multi-Channel equipment-including: air, Fire, Admin, & Service ne

Answer questions 27 through 30 only if you had experience as GHQ Chief in the position indicated on the cover leaf or if you are a Public Information Officer whether attached to GHQ or not.

27. Enter the estimated number of calls your organization (i.e., service organization, public information organization) must be prepared to handle during a busy shift at GHQ (or as P.I.O.) during a large multiple fire situation based on your experience of 3,500 (Number) men on the fire lines and 10 (Number) Fire Camps.

GHQ Fire Boss ~~and P.I.O~~. Telecommunications Requirements

To and From Contacts	Estimated No. of Calls Initiated and Received Per Hour					
	By Radio		By Telephone		By Other Means (State Which)	
	Initiate	Receive	Initiate	Receive	Initiate	Receive
Fire Camps: Fire Bosses	2-5	2-5				
Service Organizations			5-10	5-10		
Planning Organizations			5-10	5-10		
Public Information Officer			5-10	10-20		
Other:						
Outside Sources of Supply			5-10	1-2		
Outside Public			—	10-20		
Adjoining Forests			Less than 1	Less than 1		
S. O. of Involved Forest (if GHQ is not in S.O.)			2 to 5	2 to 5		
Zone Dispatchers			less than 1	less than 1		
Regional Dispatchers			"	"		
R. O. (Other than Dispatcher)			"	"		
Washington Office			—	—		
Air Bases			"	"		
Other:						

28. What is usually the size of your organization (i.e., number of personnel assigned to you to handle your function): 40-60 people in GHQ

29. Describe your present telecommunications situation at GHQ or in your capacity as P.I.O. Forest Radio Net is backbone, also Air Net, One or more Fire Nets, Service Net, Radio-Telephone + if at all possible a commercial telephone (2 to 5 lines). Also local intercom - telephone + loud speaker system.

30. What improvements in telecommunications are needed to facilitate your GHQ job (list in order of priority): (1) Better cross communications with coop agencies.
(2) More reliable communications with all Fire Zones & Forest Dispatches & air operations

Exhibit B2. **Fire occurrence** in sample forests for selected areas.

REGION 1 Area B1

JULY 1960

Date	Forest	No. of Fires	Dates Burned	Acres
1	St. Joe	1		-
4	Nezperce	1		-
7	Nezperce	1		-
8	St. Joe	1		5
9	St. Joe	1		-
	Bitterroot	8		-
10	Bitterroot	1		-
		1		11
	Nezperce	1	7/10	17
11	Bitterroot	3		-
	Nezperce	1	7/11	32
		1	7/11 - 7/17	2
12	Bitterroot	3		-
	Nezperce	1		-
		1	7/12 - 7/14	110
13	Bitterroot	3		-
		1		4.5
	St. Joe	27		-
	Clearwater	17		-
		2		0.5@
	Nezperce	4	7/13	-
		3	7/13 -7/14	-
		1	7/13 - 7/15	-
		3	7/13 - 7/16	-
		1	7/13	3
		1	7/13 - 7/14	3
		1	7/13	4
		1	7/13	1
14	Bitterroot	4		-
		1		6
		1	7/14 - 7/16	13
	Nezperce	1		-
		1	7/14 - 7/17	3
15	Bitterroot	2		-
	Nezperce	1	7/15 - 7/16	-
		1	7/15 - 7/18	-
		1	7/15	58
16	St. Joe	1		7
	Nezperce	1	7/16 - 7/18	2
17	Nezperce	1	7/17	46
18	St. Joe	1		-
	Clearwater	1		-
	Nezperce	1	7/18 - 7/19	-
19	Bitterroot	1		-
		1		5.5

Exhibit B2. (cont.)

19	Clearwater	3		-
		1		5
	Nezperce	5		-
		5	7/19 - 7/20	-
		2	7/19 - 7/21	-
		1	7/19 - 7/24	-
		1	7/19 - 7/23	1750
		1	7/19 - 7/20	32
		1	7/19 - 7/21	139
		1	7/19 - 7/20	2
		1	7/19 - 7/20	11
		1	7/19 - 7/20	1
		1	7/19 - 7/27	5719
		1	7/19 - 7/21	2
		1	7/19 - 7/19	1
20	Bitterroot	2	7/20 - 7/21	-
		2	7/20	-
		1	7/20 - 7/26	3050
	St. Joe	12	7/20	-
		1	7/20	8
		2	7/20	1@
	Clearwater	15	7/20	-
		1	7/20	2.5
		1	7/20	1
		1	7/20	4.5
		1	7/20	3
21	Bitterroot	10		-
		1	7/21 - 7/22	40
		2		.5@
	St. Joe	1		-
22	Bitterroot	2		-
		1		2
25	Bitterroot	1		-
26	Bitterroot	1		-
27	Bitterroot	1		-
	St. Joe	1	7/27 - 7/28	74
	Nezperce	2	7/27 - 7/28	-
28	Nezperce	1	7/27 - 7/28	2
	Bitterroot	1		-
29	Bitterroot	2		-
30	Bitterroot	1		-
	Nezperce	2		-
31	Nezperce	1	7/31 - 8/1	-

Exhibit B2. (cont.)

REGION 1 Area B1

JULY 1961

Date	Forest	No. of Fires	Dates Burned	Acres
3	Bitterroot	1		1.5
5	Bitterroot	7		-
		1	7/5 - 7/18	5
		1	7/5 - 7/18	19
	Clearwater	6		-
	St. Joe	1		-
	Nezperce	5	7/5	-
		6	7/5 - 7/6	-
		2	7/5 - 7/8	-
		1	7/5 - 7/13	-
6	Bitterroot	2		-
		1		1
	Clearwater	13		-
		1		1
	Nezperce	2	7/6	-
		2	7/6 - 7/7	-
		2	7/6 - 7/10	-
7	Clearwater	1		-
		1		4
8	Clearwater	1		-
9	Bitterroot	1		6
	Nezperce	1	7/9 - 7/15	-
14	Bitterroot	2		-
	Clearwater	1		-
		1		3
	Nezperce	2	7/14 - 7/16	-
15	Bitterroot	3	7/15	-
		1	7/15 - 7/20	-
		1	7/15 - 7/17	300
	Nezperce	1	7/15 - 7/20	-
16	Nezperce	2	7/16 - 7/18	-
17	Clearwater	1		-
18	Bitterroot	1		-
20	Bitterroot	1		-
22	Nezperce	1	7/22 - 7/23	-
23	Bitterroot	2		-
	Clearwater	3		-
	St. Joe	10		-
		1		1
	Nezperce	2		-
24	Bitterroot	1	7/24 - 8/13	17,960
25	Bitterroot	1		-
	St. Joe	1		-
26	Clearwater	3		-

Exhibit B2. (cont.)

27	Bitterroot	7	7/27	-
		2	7/27 - 7/28	-
		1	7/27 - 8/2	4
		1	7/27	12
	Clearwater	1	7/27	-
		1	7/27	.5
	Nezperce	8		-
29	Bitterroot	1		-
30	Clearwater	1		-
	St. Joe	2		-
31	Clearwater	1	7/31 - 8/2	930
		1	7/31 - 8/1	449

Exhibit B2. (cont.)

REGION 1 Area B1

AUGUST 1961

Date	Forest	No. of Fires	Dates Burned	Acres
3	Bitterroot	1		3
		1		2
4	Bitterroot	4		-
		1	8/4 - 8/19	28,002
		1		1
	Clearwater	1	8/4 - 8/23	2,780
		1	8/4 - 8/10	27
		1	8/4 - 8/6	15
		1		7
		1		4
		1		1.25
		1	8/4 - 8/23	3,895
		1	8/4- 8/6	11
		1	8/4 - 8/6	22.5
		1	8/4 - 8/10	1,108
		1		-
	Nezperce	1		-
		2	8/4 - 8/8	-
		1	8/4 - 8/11	1,240
5	Clearwater	1		-
6	Clearwater	1		-
	Nezperce	2		-
7	Clearwater	1		-
		1	8/7 - 8/8	90
8	Nezperce	4		-
9	St. Joe	1		-
10	Clearwater	2		-
14	Bitterroot	3		-
	Nezperce	1	8/14 - 8/16	-
15	Bitterroot	31		-
		1		7
		1	8/15 - 8/17	26
		1	8/15 - 8/20	18
		1	8/15 - 8/28	12
		1		2
		1	8/15 - 8/21	510
		1		1
	Clearwater	21		-
		2		1@
		2		2@
	St. Joe	73		-
		1		8
		1		6
		1		5
		2		1@

Exhibit B2. (cont.)

15	Nezperce	1	8/15 - 8/17	210
		1	8/15 - 8/22	365
		1	8/15 - 8/18	10
		1	8/15 - 8/24	4,545
		24	8/15	-
		25	8/15 - 8/16	-
		7	8/15 - 8/17	-
		1	8/15 - 8/20	-
		1	8/15 - 8/21	-
16	Bitterroot	1		-
	Clearwater	2		-
	St. Joe	3		-
17	Clearwater	1		1
18	Clearwater	1		3
	Nezperce	1		-
19	Nezperce	2		-
		1	8/19 - 8/20	-
21	Bitterroot	1		-
	Clearwater	1		53
	St. Joe	2		-
22	Bitterroot	21		-
		1		8
		1	8/22 --8/23	25
		1		2.5
		1		1.5
	Clearwater	8		-
		1		2
		2		1@
	Nezperce	6		-
		1	8/22 - 8/23	-
23	Bitterroot	2		-
		1		1
	Clearwater	1		-
	St. Joe	22		-
		1		1
24	Bitterroot	8		-
		2		1@
	Clearwater	36		-
		5		1@
		3		2@
		1	8/24 - 8/27	
		1	8/24 - 8/27	20
		1	8/24 - 8/27	18
		1		3.5
	St. Joe	8		-
		1		2
		1	8/24 - 8/25	22
	Nezperce	2	8/24 - 8/25	-
		2	8/24 - 8/26	-
25	Clearwater	3		-

Exhibit B2. (cont.)

26	Bitterroot	3		-
	Clearwater	1		-
27	Bitterroot	1		-
28	Bitterroot	36		-
		1	8/28 - 8/30	100
		1		2
		3		1
		1		3
		1		6
	Clearwater	18		-
		2		-
	St. Joe	2		-
29	Bitterroot	17		-
		1	8/29	300
	Clearwater	13		-
		1		3
	St. Joe	5		-

Exhibit B2. (cont.)

REGION 1 Area B1

AUGUST 1966

Date	Forest	No. of fires	Dates Burned	Acres
1	St. Joe	1	8/1 - 8/2	180
3	St. Joe	1		-
	Bitterroot	25		-
		1		1
	Nezperce	1		-
		1	8/3	10
4	Nezperce	1	8/4	-
	Bitterroot	15		-
5	Nezperce	1		-
	Bitterroot	3		-
		1	8/5	10
7	Bitterroot	1		-
10	Bitterroot	1		-
13	St. Joe	2		-
	Clearwater	1		-
	Bitterroot	1		-
	Nezperce	1	8/13 - 8/14	-
		1		-
17	Nezperce	1		-
19	St. Joe	1		-
21	Clearwater	1		-
22	Bitterroot	1		1
	Nezperce	1		-
25	Bitterroot	6		-
		2		1@
		1		3
		1	8/25 - 8/27	85
	Nezperce	2	8/25 - 8/26	-
26	Clearwater	11		-
	Bitterroot	4		-
	St. Joe	3		-
	Nezperce	1	8/26	-
		11	8/26 - 8/27	-
		3	8/26 - 8/28	-
27	Bitterroot	2		-
	Clearwater	1		-
	Nezperce	1		-
		1	8/27 - 8/28	-
		1	8/27 - 8/29	-
28	Bitterroot	1		-
	Nezperce	1	8/28 - 8/30	-
		1	8/28 - 8/31	-
30	Nezperce	1		-

Exhibit B2. (cont.)

REGION 4 Area B1

JULY 1960

Date	Forest	No. of Fires	Dates Burned	Acres
1	Boise	2		-
2	Boise	1		-
	Payette	1		-
3	Payette	1		-
4	Boise	2		-
	Salmon	2		-
	Sawtooth	1		-
5	Boise	4		-
	Payette	3		-
	Salmon	2		-
6	Payette	1	7/6 - 7/7	27
	Salmon	1		-
7	Boise	2		-
	Payette	1		-
	Salmon	1		-
	Sawtooth	2		-
8	Boise	2		-
9	Boise	1		65
	Payette	2		-
	Salmon	1		-
10	Boise	1		-
		1	7/10	567
12	Boise	1		-
	Payette	1		-
	Salmon	1		29
		1		-
13	Boise	12		-
		1	7/13 - 7/15	1,540
	Payette	19		-
		1	7/13 - 7/14	31
	Salmon	5		-
	Sawtooth	1		-
		1	7/13 - 7/16	9187
14	Boise	3		-
		1	7/14 - 7/15	12
		1	7/14	652
	Payette	3		-
	Salmon	1		-
	Sawtooth	1		-
15	Boise	1		-
	Sawtooth	1		-
16	Boise	1		-
	Payette	1	7/16	220
	Salmon	1	7/16 - 7/18	15

Exhibit B2. (cont.)

17	Boise	1	7/17	185
	Payette	1		-
		1	7/17	165
	Salmon			-
18	Boise	1		-
19	Boise	1	7/19	160
	Payette	4		-
		1	7/19 - 7/28	11,967
	Salmon	1		-
20	Boise	1	7/20 - 7/22	6,880
		1	7/20	950
	Payette	1	7/20 - 7/21	20
		3		-
	Salmon			-
21	Payette	1		-
	Sawtooth	1		76
22	Payette	1	7/22 - 7/23	60
	Salmon	13		-
23	Salmon	11		-
		1	7/23 - 7/24	20
		1	7/23 - 7/24	43
		1	7/23 - 7/26	1,156
	Sawtooth	1		-
24	Payette	2		-
25	Salmon	1		-
26	Payette	1		-
	Sawtooth	1		28
		1		-
		1	7/26	100
27	Boise	2		-
	Payette	1		-
28	Boise	1		-
	Payette	1		-
	Salmon	1		-
	Sawtooth	1		-
30	Boise	3		-
	Salmon	1		-
	Sawtooth	1		-
31	Boise	8		-
	Payette	4		-

Exhibit B2 (cont.)

REGION 4 Area B1

JULY 1961

Date	Forest	No. of Fires	Dates Burned	Acres
2	Salmon	1	7/2	340
	Sawtooth	1		-
4	Payette	1		-
5	Boise	9		-
	Payette	7		-
	Salmon	5		-
	Sawtooth	2		-
6	Boise	4		-
	Payette	1		-
	Salmon	3		-
7	Boise	3		-
	Salmon	1		-
	Sawtooth	1		-
8	Boise	1	7/8 - 7/10	37
	Salmon	1	7/8	18
		1	7/8 - 7/9	15
9	Boise	1	7/9 - 7/11	24
	Salmon	2		-
	Sawtooth	1		-
10	Boise	1		-
	Salmon	2		-
12	Payette	1		-
	Sawtooth	1		-
14	Payette	1		-
	Salmon	2		-
15	Payette	2		-
16	Boise	1		-
	Payette	2		-
	Salmon	1		-
	Sawtooth	1		-
17	Sawtooth	1		-
		1	7/17	540
18	Boise	1		-
	Salmon	1		-
	Sawtooth	1		-
19	Boise	1	7/19 - 7/21	620
20	Boise	1		-
21	Sawtooth	1		-
22	Boise	2		-
	Payette	1		-
	Salmon	1		-
23	Payette	2		-
		1	7/23 - 7/25	1,585
		1	7/23 - 7/30	920

Exhibit B2. (cont.)

24	Boise	1		-
	Payette	1		-
	Salmon	1		-
		1	7/24 - 8/13	17,960
	Sawtooth	1		-
25	Boise	2		-
	Payette	1		-
	Sawtooth	1		-
26	Boise	2		-
	Sawtooth	4		-
27	Sawtooth	2		-
28	Salmon	1		-
	Sawtooth	1		-
29	Sawtooth	1		-
30	Payette	1		-
	Sawtooth	1		-
31	Payette	1		-

Exhibit B2. (cont.)

REGION 4 Area B1

AUGUST 1961

Date	Forest	No. of Fires	Dates Burned	Acres
1	Payette	1		-
	Sawtooth	2		-
2	Salmon	1		-
	Sawtooth	2		-
3	Boise	6		-
		1	8/3 - 8/4	12
	Payette	1		-
	Salmon	1		-
		1	8/3 - 8/4	38
		1	8/3 - 8/7	2,030
	Sawtooth	1	8/3 - 8/5	425
4	Boise	4		-
	Payette	1		-
5	Boise	7		-
	Sawtooth	2		-
6	Boise	1		-
	Payette	1		-
7	Payette	1	8/7 - 8/8	3,087
8	Payette	3		-
9	Boise	2		-
	Payette	4		-
	Sawtooth	1		-
		1		11
12	Boise	1		21
		6		-
13	Boise	15		-
		1		15
	Payette	5		-
	Sawtooth	4		-
14	Boise	7		-
	Sawtooth	2		-
15	Boise	23		-
		1	8/15 - 8/16	480
	Payette	18		-
	Salmon	9		-
	Sawtooth	2		-
		1		35
16	Boise	7		-
	Payette	6		-
	Salmon	3		-
	Sawtooth	1		-
17	Payette	1	8/17 - 8/18	15
	Salmon	1	8/17 - 8/21	1,960
	Sawtooth	1	8/17 - 8/18	35
		1	8/17 - 8/19	10

18	Payette	2		-
	Salmon	1		-
19	Boise	4		-
	Payette	1		-
	Sawtooth	1		19
20	Payette	2		-
21	Boise	1		-
22	Payette	2		-
	Salmon	2		-
23	Boise	2		-
	Payette	1		-
24	Payette	2		-
25	Boise	2		-
	Payette	2		-
	Sawtooth	1		-
26	Boise	1		-
	Payette	1		-
	Sawtooth	1		-
27	Sawtooth	4		-
28	Boise	1	8/28 - 8/29	15
		22		-
	Payette	15		-
	Salmon	1		28
		11		-
29	Boise	3		-
	Payette	6		-
	Salmon	10		-
	Sawtooth	3		-
30	Boise	1		-
	Payette	2		-
	Salmon	4		-
	Sawtooth	1		-
31	Payette	1		-
	Sawtooth	1		-

Exhibit B2. (cont.)

REGION 4 Area B1

AUGUST 1966

Date	Forest	No. of Fires	Dates Burned	Acres
1	Sawtooth	1		-
2	Salmon	1		-
3	Boise	2		-
		1		30
	Payette	3		-
	Salmon	5		-
	Sawtooth	2		-
4	Boise	25		-
		1	8/4 - 8/5	78
		1	8/4 - 8/7	85
		1	8/4	1,250
		1	8/4 - 8/10	12,706
		1	8/4	105
	Payette	9		-
	Salmon	13		-
5	Boise	3		-
	Payette	4		-
	Salmon	1	8/5 - 8/6	40
		1	8/5 - 8/6	11
		1	8/5	198
		2		-
6	Boise	2		-
	Payette	1		-
	Salmon	1		-
	Sawtooth	1		-
7	Payette	1		-
8	Salmon	3		-
10	Salmon	1		-
11	Boise	1		-
	Payette	2		-
14	Boise	1		-
16	Payette	1		-
17	Boise	1		-
	Salmon	1		-
	Sawtooth	1		-
18	Boise	1		-
	Payette	1		-
	Salmon	1		-
24	Boise	1		-
25	Payette	4		-
		1	8/25 - 8/27	80
	Salmon	7		-
		1	8/25	420
	Sawtooth	1	8/25 - 8/28	66,450
26	Boise	14		-
	Payette	15		-
	Salmon	3		-

Exhibit B2. (cont.)

27	Boise	6		-
	Payette	4		-
	Salmon	2		-
28	Boise	1		-
		1	8/28 - 8/29	15
	Payette	4		-
	Salmon	1		-
29	Boise	2		-
	Payette	2		-
	Sawtooth	2		-
30	Boise	1		-
	Payette	1		-

Exhibit B2. (cont.)

REGION 6 Area B1

JULY 1960

Date	Forest	No. of Fires	Dates Burned	Acres
1	Umatilla	1		1
		1		4
	Wallowa Whitman	1		1
8	Umatilla	1		-
9	Wallowa Whitman	2		11,1
13	Wallowa Whitman	1		2
14	Wallowa Whitman	1		1
15	Wallowa Whitman	1		5
		1		10
16	Wallowa Whitman	1		2
17	Umatilla	1	7/17	41
	Wallowa Whitman	1		140
18	Wallowa Whitman	1		3
19	Umatilla	1		2
		1		-
		1		35
		1	7/19	102
		1	7/19 - 7/21	290
		1	7/19 - 7/25	320
		1	7/19 - 7/20	1,567
		1	7/19 - 7/29	8,890
	Wallowa Whitman	6		0,1,0,0,0,0
		1		60
		1		70
		1	7/19 - 7/22	1,012
		1	7/19 - 7/29	7,205
		1	7/19 - 7/23	11,456
		1	7/19 - 7/29	19,000
20	Wallowa Whitman	17		33
		1	7/20	25
		1	7/20	50
		1	7/20	120
		1	7/20 - 7/21	160
		1	7/20 - 7/22	240
		1	7/20	100
		1	7/20 - 7/21	395
		1		678
		1	7/20 - 7/21	1,411
		1	7/20 - 7/23	1,957
		1	7/20 - 7/21	3,455
		1	7/20 - 7/22	3,904
	Umatilla	27		73
		1		20
		1	7/20 - 7/22	30
		1		25

	Umatilla	1	7/20 - 7/21	24
		1	7/20	20
		1	7/20	12
		1	7/20	47
		1	7/20	20
		1	7/20	15
		1	7/20	40
		1	7/20 - 7/23	104
		1	7/20 - 7/22	140
		1	7/20 - 7/21	177
		1	7/20	140
		1	7/20	211
		1	7/20 - 7/31	8,140
		1	7/20 - 7/31	3,780
21	Umatilla	4	7/21	1,1,3,1
		1	7/21	85
	Wallowa Whitman	1		1
22	Umatilla	3	7/22	2,3,7
		1	7/22 - 7/25	110
	Wallowa Whitman	3		1,1,2
		1	7/22 - 7/24	215
23	Umatilla	4	7/22	8,5,2,0
		1	7/23 - 7/25	6
		1	7/23 - 7/27	2
	Wallowa Whitman	2		1,1
24	Umatilla	1	7/24	2
26	Umatilla	3	7/26	1,2,0
		1	7/26 - 7/28	30
	Wallowa Whitman	2		3,5
		1	7/26	200
27	Umatilla	2	7/27	2,1
		1	7/27 - 7/28	11
	Wallowa Whitman	2		-
28	Umatilla	1		1
	Wallowa Whitman	2		1,1
29	Umatilla	1		2
30	Umatilla	1		1
31	Umatilla	1		-
	Wallowa Whitman	1		-

Exhibit B2. (cont.)

REGION 6 Area B1

JULY 1961

Date	Forest	No. of Fires	Date Burned	Acres
1	Umatilla	1		12
10	Wallowa Whitman	1		-
14	Umatilla	4	7/14	0,3,1,3
		1	7/14 - 7/16	924
		1	7/14 - 7/16	8,070
	Wallowa Whitman	1		-
		1	7/14	720
		1	7/14	1,340
15	Umatilla	1		220
18	Umatilla	1		-
21	Wallowa Whitman	1		-
22	Umatilla	1		-
25	Umatilla	1		4
28	Wallowa Whitman	1		25
29	Wallowa Whitman	1		25
30	Wallowa Whitman	1		4

REGION 6 Area B1

AUGUST 1961

Date	Forest	No. of Fires	Dates Burned	Acres
3	Umatilla	1		80
		1		100
		5		0,2,1,3,
		1	8/3 - 8/6	180
4	Wallowa Whitman	1		40
5	Umatilla	2		5,0
6	Wallowa Whitman	1		4
8	Wallowa Whitman	1		15
10	Umatilla	1	8/10	622
		1	8/10	295
12	Umatilla	1		6
14	Umatilla	2		2,2
		1	8/14	40
	Wallowa Whitman	1		5
15	Umatilla	4		1,2,4,1
	Wallowa Whitman	8		1,0,1,0,4,1,2,
16	Umatilla	1		3
	Wallowa Whitman	1		-
17	Umatilla	1	8/17 - 8/18	175
		1		2
18	Umatilla	1		16
	Wallowa Whitman	1		4
19	Wallowa Whitman	3		1,3,2
20	Umatilla	1		3
21	Umatilla	1		-
22	Umatilla			1
	Wallowa Whitman	1		-
		1		37
		1	8/22	255
		1	8/22	265
23	Umatilla	3		0,0,5
	Wallowa Whitman	2		0,0
24	Umatilla	3		2,2,1
	Wallowa Whitman	1		3
29	Wallowa Whitman	1		1
30	Umatilla	1		1

Exhibit B2. (cont.)

REGION 6 Area B1

AUGUST 1966

Date	Forest	No. of Fires	Dates Burned	Acres
1	Umatilla	1		2
		1	8/1 - 8/2	120
	Wallowa Whitman	1		2
2	Wallowa Whitman	4		1,1,1,1
3	Wallowa Whitman	2		2,0
4	Wallowa Whitman	1		-
6	Wallowa Whitman	1	8/6	80
11	Umatilla	1	8/11	80
18	Umatilla	1	8/18	193
	Wallowa Whitman	1	8/18	1,245
20	Umatilla	1		28
31	Umatilla	1		-

Exhibit B2. (cont.)

REGION 5 Area B2

JULY 1961

Date	Forest	No. of Fires	Dates Burned	Acres
1	Los Padres	1		-
2	Angeles	2		-
3	Angeles	1		-
	Cleveland	1		-
4	San Bernardino	1		-
6	San Bernardino	1		-
7	San Bernardino	1		-
8	Angeles	1		18
	Los Padres	1		-
9	San Bernardino	1		-
10	Angeles	1		-
	Cleveland	1	7/10	205
11	San Bernardino	1		-
12	Cleveland	1		-
14	Los Padres	1	7/14	370
	San Bernardino	1		-
		1	7/14	161
15	Angeles	1		-
16	Angeles	1	7/16	105
	San Bernardino	1		-
17	Angeles	1	7/17 - 7/24	14,737
18	Angeles	1		-
	San Bernardino	1		-
19	Angeles	1		34
		1	7/19 - 7/26	27,790
	San Bernardino	1		-
20	Angeles	13		-
		1	7/20 - 7/22	970
		1	7/20 - 7/28	22,146
		1	7/20 - 7/22	2,560
	Cleveland	3		-
	Los Padres	1		30
	San Bernardino	1	7/20 - 7/22	1,596
		20		-
21	Cleveland	3		-
		1	7/21 - 7/24	2,010
	Los Padres	1		35
		1	7/21 - 7/29	12,216
	San Bernardino	25		-
22	Cleveland	1		-
	Los Padres	2		-
	San Bernardino	5		-
23	Angeles	1		-
	Los Padres	1		-
	Cleveland	1		-

Exhibit B2. (cont.)

24	San Bernardino	1		-
25	San Bernardino	1		-
26	Angeles	2		-
27	Angeles	1		-
		1	7/27 - 7/29	580
	Los Padres	1		-
	San Bernardino	1		-
28	San Bernardino	3		-

Exhibit B2 (cont.)

REGION 5 Area B2

JUNE 1966

Date	Forest	No. of Fires	Dates Burned	Acres
1	San Bernardino	1		-
4	Cleveland	1		-
	Los Padres	1		-
	San Bernardino	1		-
5	Los Padres	1		-
	San Bernardino	1		-
11	Los Padres	1	6/11	500
		1		80
12	Angeles	1		-
	Los Padres	1		14
		1	6/12 - 6/22	93,000
	San Bernardino	1		-
13	San Bernardino	1		-
14	San Bernardino	2		-
15	Angeles	1		-
	Los Padres	3		-
	San Bernardino	10		-
16	Los Padres	1		-
17	San Bernardino	1		-
		1		14
18	Cleveland	1		-
	San Bernardino	1		-
19	Cleveland	1		-
20	San Bernardino	1		-
	Los Padres	1		-
21	Los Padres	1		20
		1		18
	San Bernardino	1	6/21 - 6/23	27,000
23	Cleveland	2		-
24	Los Padres	1		-
	San Bernardino	1		-
25	San Bernardino	1		-
27	Los Padres	1		-
28	Los Padres	1		40
	Cleveland	1		30
29	Angeles	1		-
		1	6/29	375

Exhibit B2. (cont.)

REGION 5 — Area B2

SEPTEMBER 1970

Date	Forest	No. of Fires	Dates Burned	Acres
1	Cleveland	1		-
	Los Padres	1		-
	San Bernardino	1		-
3	Cleveland	1		-
	Los Padres	2		-
4	Cleveland	1		-
		1		65
	Los Padres	1		1
	San Bernardino	2		-
5	San Bernardino	2		-
6	Angeles	1		-
	Cleveland	3		-
		1	9/6 - 9/8	1,361
	San Bernardino	2		-
		1	9/6 - 9/8	14,457
7	Cleveland	1		45
	Los Padres	2		-
	San Bernardino	1		-
8	San Bernardino	1		-
9	San Bernardino	1		-
10	Los Padres	1		-
11	Angeles	1		-
	Cleveland	4		-
12	Angeles	1		-
	Los Padres	1		-
13	Cleveland	2		-
	San Bernardino	2		-
14	Angeles	1	9/14	158
	Cleveland	1		-
	Los Padres	1	9/14 - 9/15	10
15	Los Padres	1		-
16	Angeles	1		-
	San Bernardino	1		-
17	Angeles	1		-
20	Angeles	1		-
	Los Padres	1		-
21	Angeles	1		-
22	Angeles	1		-
	Cleveland	2		-
24	San Bernardino	1		-
25	Angeles	1		-
		1	9/25	450
		1	9/25 - 9/27	23,790
	Cleveland	3		-
	Los Padres	3		-
	San Bernardino	1		-

Exhibit B2. (cont.)

26	Angeles	1		-
		1	9/26 - 10/1	3,479
		1	9/26	410
	Cleveland	6		-
		1	9/26 - 9/30	175,420
	Los Padres	1		-
	San Bernardino	1	9/26	1,400
27	Angeles	1		-
	Cleveland	2	9/27 - 9/28	36
		1	9/27 - 9/29	3,268
	Los Padres	3		-
		1	9/27 -10/5	44,000
	San Bernardino	4		-
28	Angeles	2		-
	Cleveland	1	9/28 - 10/3	12,900
	Los Padres	1		-
	San Bernardino	4		-
		1	9/28 - 10/17	33,920
29	Cleveland	1		-
	Los Padres	1		85
	San Bernardino	1		-
30	Cleveland	1		-

Exhibit B2. (cont.)

REGION 5 Area B2

NOVEMBER 1970

Date	Forest	No. of Fires	Dates Burned	Acres
1	San Bernardino	1		-
2	San Bernardino	1		-
3	San Bernardino	1		-
4	San Bernardino	1		-
5	Angeles	1		-
7	Cleveland	1		-
9	Cleveland	1		-
10	Angeles	1		-
	San Bernardino	1		-
11	Angeles	1		-
12	Angeles	1		-
	San Bernardino	1	11/12 - 11/21	2,850
13	Cleveland	2		-
	San Bernardino	1	11/13 - 11/20	53,100
		2		-
14	Cleveland	2		-
	San Bernardino	1		-
15	Los Padres	1		-
	San Bernardino	1		-
16	Angeles	1		-
17	Los Padres	1		-
18	Los Padres	1		-
	San Bernardino	1		-
19	San Bernardino	1		-
21	Cleveland	1		15
		2		-
22	San Bernardino	1		-
23	San Bernardino	1		-
26	Los Padres	1		-

Exhibit B2. (cont.)

REGION 6 Area B3

AUGUST 1961

Date	Forest	No. of Fires	Dates Burned	Acres
2	Okanogan	1		1
4	Wenatchee	1		4
6	Snoqualmie	1		2
7	Wenatchee	1		4
	Snoqualmie	1		1
8	Wenatchee	1		1
	Okanogan	1	8/8	60
11	Wenatchee	1	8/11	750
14	Gifford Pinchot	6		2,1,1,1,1,
		1	8/14 - 8/16	2
	Snoqualmie	2		0,1
		1	8/14	14
15	Wenatchee	2		0,1
		1	8/15	67
	Okanogan	2		0,6'
		1	8/15	35
16	Wenatchee	1	8/16	125
		1	8/16	21
	Gifford Pinchot	4		2,2,0,0
	Okanogan	1		1
		1		12
18	Gifford Pinchot	1		-
19	Wenatchee	2		1,3
	Snoqualmie	1	8/19 - 8/20	2
20	Wenatchee	1		1
21	Gifford Pinchot	2		8,6
22	Wenatchee	8		2,0,0,5,2,2,1,
		1	8/22	540
	Gifford Pinchot	6		1,1,1,1,2,6
	Okanogan	2		1,1
		1		27
	Snoqualmie	6		5,1,0,2,1,2
24	Wenatchee	1	8/24 - 8/25	18
	Okanogan	1		1
28	Gifford Pinchot	1		1
29	Wenatchee	1		1
	Snoqualmie	1		1
30	Wenatchee	1		14
	Snoqualmie	1		1

Exhibit B2. (cont.)

REGION 6 Area B3

AUGUST 1968

Date	Forest	No. of Fires	Dates Burned	Acres
1	Gifford Pinchot	1	8/1 - 8/3	56
	Wenatchee	1		2
2	Snoqualmie	1		1
4	Snoqualmie	1		2
	Okanogan	1		-
	Gifford Pinchot	1	8/4	63
	Wenatchee	1	8/4 - 8/11	27,120
5	Wenatchee	1	8/5 - 8/7	1,210
6	Wenatchee	1		5
10	Snoqualmie	1		1
12	Wenatchee	1		7
13	Gifford Pinchot	1		-
22	Snoqualmie	1		-
26	Okanogan	1		-
29	Wenatchee	1		-

Exhibit B2. (cont.)

REGION 6 Area B3

JULY 1970

Date	Forest	No. of Fires	Dates Burned	Acres
1	Wenatchee	2		-
	Gifford Pinchot			
2	Wenatchee	2		-
3	Snoqualmie	1		-
	Wenatchee	3		-
4	Snoqualmie	1		-
	Wenatchee	3		-
	Okanogan	5		-
5	Snoqualmie	3		-
	Wenatchee	1		-
	Okanogan	1		-
	Gifford Pinchot	2		-
6	Wenatchee	2		-
7	Snoqualmie	1		-
	Wenatchee	2		-
8	Snoqualmie	1		-
	Okanogan	1		15
	Gifford Pinchot	1		-
9	Snoqualmie	2		-
10	Wenatchee	2		-
	Okanogan	1		-
	Gifford Pinchot	1		-
11	Snoqualmie	1		-
	Wenatchee	2		-
12	Wenatchee	3		-
	Okanogan	2		-
	Gifford Pinchot	1		-
13	Wenatchee	2		-
	Okanogan	3		-
	Gifford Pinchot	1		-
14	Wenatchee	1		-
15	Wenatchee	3		-
	Okanogan	1		-
16	Snoqualmie	36		-
		1		11
	Wenatchee	27		-
		1	7/16 - 7/31	15,725
		1	7/16	15
	Okanogan	46		-
		1	7/16 - 7/20	50
		1	7/16 - 7/18	75
		1	7/16 - 7/17	25
		1	7/16 - 7/20	75
		1	7/16 - 7/19	130
		1	7/16 - 7/19	280
		1	7/16 - 7/19	202

Exhibit B2. (cont.)

16	Okanogan	1	7/16 - 7/17	15
		1	7/16 - 7/21	650
		1	7/16 - 7/22	238
		1	7/16 - 7/23	6,130
		1	7/16 - 7/17	145
		1	7/16 - 7/18	1,240
	Gifford Pinchot	5		-
17	Snoqualmie	5		-
	Wenatchee	6		-
	Okanogan	8		-
		1	7/17 - 7/20	80
		1	7/17 - 7/20	15
18	Snoqualmie	5		-
	Wenatchee	2		-
	Okanogan	7		-
		1	7/18 - 7/26	2,080
		1	7/18 - 7/20	21
	Gifford Pinchot	2		-
19	Snoqualmie	6		-
	Wenatchee	4		-
	Okanogan	2		-
		1	7/19 - 7/24	410
		1	7/19	10
20	Snoqualmie	4		-
	Okanogan	1	7/20	25
	Gifford Pinchot	1		-
21	Wenatchee	1		-
	Okanogan	2		-
22	Wenatchee	1		-
	Okanogan	1		-
		1	7/22	25
23	Snoqualmie	4		-
	Okanogan	3		-
	Gifford Pinchot	2		-
24	Snoqualmie	1		-
	Wenatchee	2		-
25	Snoqualmie	1		-
	Wenatchee	2		-
26	Wenatchee	1		-
27	Wenatchee	2		-
28	Wenatchee	1		-
29	Okanogan	1		-
30	Snoqualmie	1		-
	Wenatchee	1		-

Exhibit B2. (cont.)

REGION 6 Area B3

AUGUST 1970

Date	Forest	No. of Fires	Dates Burned	Acres
1	Wenatchee	3		-
2	Wenatchee	1		-
	Gifford Pinchot	1		-
3	Wenatchee	1		-
	Okanogan	1		-
	Gifford Pinchot	1		-
4	Wenatchee	1		-
5	Snoqualmie	1		-
	Wenatchee	1		-
6	Wenatchee	16		-
7	Snoqualmie	1		-
	Wenatchee	1		-
8	Wenatchee	2		-
9	Snoqualmie	2		-
	Wenatchee	2		-
	Gifford Pinchot	1		-
10	Snoqualmie	1		-
	Wenatchee	2		-
	Gifford Pinchot	2		-
11	Snoqualmie	1		-
	Wenatchee	1		-
12	Snoqualmie	1		-
	Wenatchee	1		-
	Okanogan	2		-
	Gifford Pinchot	1		-
13	Gifford Pinchot	1		-
14	Wenatchee	1		-
	Gifford Pinchot	1		-
15	Wenatchee	1		-
	Gifford Pinchot	5		-
16	Snoqualmie	3		-
	Wenatchee	2		-
	Gifford Pinchot	2		-
17	Wenatchee	3		-
18	Wenatchee	1		-
	Gifford Pinchot	2		-
19	Wenatchee	3		-
	Gifford Pinchot	1		-
20	Snoqualmie	2		-
	Wenatchee	1		-
	Gifford Pinchot	1		-
21	Okanogan	1		-
	Gifford Pinchot	1		-

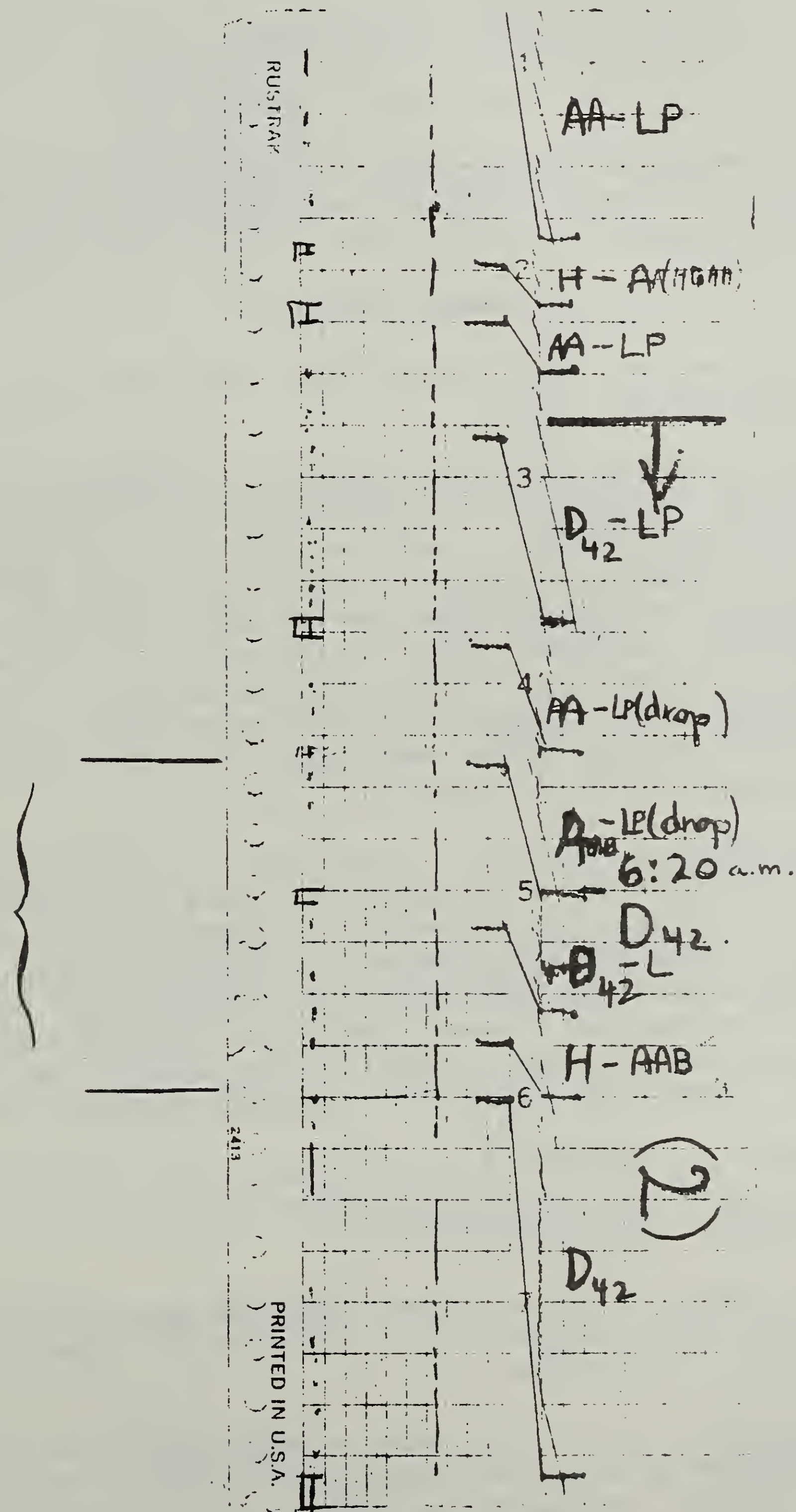
Exhibit B2. (cont.)

22	Snoqualmie	1		-
	Wenatchee	3		-
	Okanogan	1		-
	Gifford Pinchot	2		-
23	Wenatchee	8		-
		1	8/23 - 8/31	120
		1	8/23 - 8/28	788
		1	8/23 - 8/31	55
		1	8/23 - 8/29	34
	Okanogan	2		-
		1	8/23 - 8/25	35
		1	8/23 - 8/24	16
	Gifford Pinchot	2		-
24	Snoqualmie	10		-
	Wenatchee	25		-
		1	8/24 - 9/3	42,280
		1	8/24 - 8/31	7,100
		1	8/24 - 8/31	1,950
		1	8/24 - 9/7	190
		1	8/24 - 9/7	43,118
		1	8/24 - 9/14	25
		1	8/24 - 8/29	224
		1	8/24 - 8/28	80
		1	8/24 - 8/26	90
		1	8/24 - 8/30	170
		1	8/24 - 8/30	500
		1	8/24 - 8/30	20
		1	8/24 - 8/30	65
		1	8/24 - 8/29	3,571
	Okanogan	2		-
		1	8/24 - 8/26	35
	Gifford Pinchot	3		-
25	Wenatchee	1		-
26	Snoqualmie	1		-
	Wenatchee	1		-
27	Snoqualmie	1		-
	Wenatchee	1		-
	Gifford Pinchot	1		-
29	Snoqualmie	2		-
	Wenatchee	2		-
30	Snoqualmie	14		-
	Gifford Pinchot	2		-
31	Snoqualmie	5		-
	Wenatchee	53		-
		1	8/31	15
	Okanogan	25		-
	Gifford Pinchot	17		-

Exhibit B3. Sample transcription of tape recorded air attack communications. (Taken from a tape of Lead Plane communications, Wenatchee National Forest, 7/18/70- 5:30 - 9:00 am)

No.	Tape Length From	To	Message	
67.	212	212	Air attack, this is Lead One over.	Lead Plane-Air Attack Boss
68.	212	212	Go ahead Lead.	
69.	212.5	213	How about us coming in, we can get it real good this way, and put a tank at a time right down this way on this edge of the fire and then we'll just keep working down the hill, over	
70.	213	213.5	10-4; that looks good, then it'll roll back here to the fire that way. That's a perfect kind of attack, over	
(Time: 6:19:00)				
71.	213.5	214	Tanker 42,come around and we'll hit the fire line here at an angle, 500 at a time	Lead Plane-Tanker 42
72.	214	214	10-4	
73.	214	214	That way it'll give you a good shot at the fire and there'll be a-- going over the hill too fast over	
74.	214	214	10-4	
75.	214	214	-60, this is air attack	Air Attack Boss-Helicopter 60
76.	214.5	214.5	60- go ahead	
77.	214.5	214.5	I see you're taking off the top fire, is that right	
78.	214.5	214.5	There'll be still one stand-by down low, coming up the canyon ~~on down~~ I'm going down	
79.	215	215	OK, we'll have to keep an eye on that tanker coming up, so lay low	

Exhibit B4. Sample strip chart recording corresponding to the transcription in Exhibit B3.



Section of chart corresponding to Exhibit B3

Exhibit B5 Sample of extra comments solicted in Question 26 of the large fire questionnaire Chief Pilot, R-6

My job as Air Coordinator for GHQ required that I spend most of my time on the telephone. I personally had very little use for radios. If I become involved with THIS job in the future I plan to:

1. Have a Call Director Telephone with several lines.

2. Encourage telephone discipline.

3. Obtain a room away from the confusion.

The need for better communication for aircraft became apparent almost immediately. We were trying to run all air activities with the Air-Net, and with the number of aircraft we had this was impossible for two reasons:

1. We did not have enough radios.

2. Had we had enough radios there would have been too much interference to operate.

We did try to assign the 122.9 frequency to some and Air-Net to others, but we were still in trouble. I decided that some additional frequencies common to aircraft were needed. A call was placed to the WO requesting three VHF frequencies normally assigned to FAA. We received two frequencies, and these were changed from time-to-time, but at least we finally had satisfactory communication. We asked that all aircraft that could monitor the Air-Net for backup. We assigned 122.9 to the helicopters and the two VHF frequencies were assigned to Air Tankers working certain sectors of the fires. Air Attack Bosses and Air Tanker Bosses were generally able to monitor all necessary frequencies where they were working.

If the situation permitted, the ideal way to operate would be to have all aircraft-airplanes and helicopters operating in a certain sector or zone use the same VHF frequencies and monitor Air-Net or 122.9 as a backup. With fifty-two helicopters and nineteen air tankers working this was not possible. We did have several instances where certain Heliport Managers and the pilots would get together and between them select and use a particular VHF frequency. I guess they had excellent communications locally, but nobody else could contact them. These situations were curtailed when we found out about them.

I am certain the folks were just trying in their own way to get the job done. This again points up the need for better communication for the management of aircraft during large fire situations.

During our larger fires this past summer we set up Air Traffic Control Towers manned by the FAA at three different locations: Omak, Winthrop, and Wenatchee in the State of Washington.

Due to the amount of traffic and the smoke conditions that prevailed, I personally believe we could not have operated without their help without killing someone. I would recommend that FAA Air Traffic Controllers be used when operating from an uncontrolled airport on any large fire situation. We had one Air National Guard Portable Tower that we used at Omak and Wenatchee that is completely self-contained, including heat, air conditioning, and radios. The Guard also furnished a maintenance man, and we had FAA Controllers man it. The portable tower is not an absolute must as one of our towers consisted of an FAA Controller sitting in the back of a pickup, and he did an excellent job

Exhibit B6 . Wenatchee telephone directory, 1970 fires.

TELEPHONE NUMBERS

RANGER STATIONS:

Chelan	682-2576*
CleElum	674-4411*
Ellensburg	962-9813*
Entiat	784-1511*
Lake Wenatchee	763-2086*
Leavenworth	548-5817*
Steliko Work Center (Entiat)	784-1976

FIRE CAMPS:

DISTRICT	FIRE	CAMP	NUMBER
Chelan	Mitchell	Alta Lake	923-2262* 923-2361* 923-2263*
		Ski Camp	687-3430* 687-3112*
		G.H.Q.	682-2211*
	Slide Ridge	25-mile	687-3552* 687-3542* 687-3769
Entiat	Gold Ridge	Ardenvoir #1	784-1348
	Cougar, Mott & Signal	Tyee #2	784-1888
	Burns		
	Fox Creek	Brief #3	784-1989
	Shady Pass	Silver Falls #4	784-1987
Lake Wenatchee	Various	Dardenels	763-2791* 762-2086*
Leavenworth	Hansel Creek		584-7888* 548-7814*
Warehouse	(Fire Cache) Orders		663-5785 663-5082 663-6314
	Truck Transport		663-4384
	Warehousemen (Feigal)		662-2097

Exhibit B6. (cont.)

Procurement	(Other)		662-5381 662-5401
Manpower			662-5022 663-4912 662-6913
Air Dispatch			662-5891 663-5330
Equipment (Orders)			663-4038 662-6487
Forest Dispatcher			663-8575 663-8511 X413 414
G.H.Q.	3-8511	Jorgenson Lewis	Ext. 456
Service Coordinator (Mienders)			Ext. 459
Communications (Thompson)			Ext. 458
Demobilization (Weir)			Ext. 457
(Enberg)			Ext. 459
Plans Coordinator (Clark)			Ext. 306
Maps and Records			Ext. 436 or 439
Fire Information			Ext. 434 or 435
Photo Interpt. (Cook)			Ext. 304

Other

Wenatchee S.O.	663-8511

Ask for extension or person

Sterling Jr. High	884-6821
Moses Lake	762-9102*
Okanogan S.O.	422-2704*
Comp. Injury (Houghin)	663-8511 Ext. 3 or 4

*Long Distance-- if on FTS call dial 8-838-4611,
ID - SU1223 and Number calling.
Hours: 0730 - 1730
After hours call 202-967-1221 or ask Operator (0) to dial

Exhibit B7. Monthly fire report and division unit estimates.

Region 1

Year	Month	Forest	Acres*	Tot. # Fires: class	Tot. # Fires: #	# Multi-Div. Fires	Estimated # Div. Units**
1960	July	Bitterroot	3,050	F	1	1	3
		Bitterroot	355	E	1	0	0
		Lewis & Clark	335	E	1	0	0
		Lolo	3,080	F	1	1	3
		Nezperce	541	E	1	0	0
		Nezperce	1,750	F	1	1	2
		Nezperce	5,719	G	1	1	3
	Nov.	Kaniksu	638	E	1	0	0
1961	July	Bitterroot	17,960	G	1	1	6
		Clearwater	930	E	1	0	0
		Clearwater	449	E	1	0	0
		Helena	2,881	F	1	1	3
	Aug.	Bitterroot	28,002	G	1	1	6
		Bitterroot	510	E	1	0	0
		Clearwater	2,780	F	1	1	3
		Clearwater	3,895	F	1	1	3
		Clearwater	1,108	F	1	1	2
		Clearwater	385	E	1	0	0
		Helena	1,170	F	1	1	2
		Nezperce	7,000	G	1	0	0
		Nezperce	365	E	1	0	0
		Nezperce	4,545	F	1	1	3
		Nezperce	810	E	1	0	0
		Nezperce	1,240	F	1	1	2
		Nezperce	450	E	1	0	0
1966	May	Custer	3,000	F	1	1	3
	July	Custer	2,086	F	1	1	2
		Custer	3,283	F	1	1	3
		Custer	1,229	F	1	1	2
		Custer	8,112	G	1	1	4
		Custer	12,832	G	1	1	4
		Custer	384	E	1	0	0
		Custer	624	E	1	0	0
		Lewis & Clark	1,033	F	1	1	2

*Average as reported in monthly fire reports

**1 division--Where(1) is shown, this does not mean one division boss, but means about 1 division worth of men and equipment. On a fire of this size the Fire Boss, Div. Boss and Line Boss are probably one man.

Exhibit B7. (cont.)

Region 1

Year	Month	Forest	Acres*	Tot. # Fires class:	#	# Multi-Div. Fires	Estimated # Div. Units**
1966	Aug.	Colville	525	E	1	0	0
		Gallatin	510	E	1	0	0
		Helena	340	E	1	0	0
		Lolo	310	E	1	0	0
	Sept.	Custer	442	E	1	0	0
1967	Aug.	Clearwater	812	E	1	1	2
		Clearwater	310	E	1	0	0
		Clearwater	1,376	F	1	1	2
		Colville	490	E	1	0	0
		Flathead	806	E	1	0	0
		Helena	315	E	1	0	0
		Kaniksu	695	E	1	0	0
		Kaniksu	1,164	F	1	1	2
		Kaniksu	16,600	G	1	1	6
		Kootenai	670	E	1	0	0
		Lolo	420	E	1	1	2
		Nezperce	465	E	1	0	0
		Nezperce	1,570	F	1	1	2
		Nezperce	3,000	F	1	1	3
		Nezperce	7,180	G	1	1	4
		Nezperce	890	E	1	1	2
		Nezperce	2,420	F	1	1	3
		Nezperce	660	E	1	0	0
	Sept.	Custer	1,210	F	1	1	2
		Flathead	815	E	1	0	0
		Kaniksu	55,910	G	1	1	9
		St. Joe	806	E	1	1	2
1968	July	Helena	1,293	F	1	1	2
		Lolo	798	E	1	1	2
	Aug.	Kootenai	811	E	1	1	2
		Nezperce	3,600	F	1	1	3
		St. Joe	350	E	1	0	0
	Nov.	Beaverhead	370	E	1	0	0

Exhibit B7. (cont.)

Region 1

Year	Month	Forest	Acres*	Tot. class	# Fires #	# Multi-Div. Fires	Estimated # Div. Units**
1969	July	Lolo	375	E	1	0	0
	Aug.	Nezperce	360	E	1	0	0
1970	Aug.	Colville	706	E	1	1	2
		Kaniksu	2,670	F	1	1	3
		Kootenai	1,110	F	1	1	2
		Kootenai	1,172	F	1	1	2
		Lewis & Clark	3,100	F	1	1	3
		Lewis & Clark	3,831	F	1	1	3
	Sept.	Colville	514	E	1	0	0
	Nov.	Flathead	1,712	F	1	1	2
		Kaniksu	374	E	1	0	0
		Kootenai	389	E	1	0	0
		Lewis & Clark	446	E	1	0	0

Exhibit B7. (cont.)

Region 2

Year	Month	Forest	Acres	Tot. class	# Fires : # 1/	# Multi-Div. Fires	Estimated # Div. Units
1960	June	Roosevelt	620	C+	2	0	0
		San Isabel	451	C+	1	0	0
		White River	250	C+	1(1)	0	0
	July	Rio Grande	388	C+	1	0	0
		Medicine Bow (600,600,400)	1,812	C+	3	1	2,0,0
	Aug.	GM-Uncompahgre	306	C+	1	0	0
		Gunnison	460	C+	4(2)	0	0
		Black Hills (6,000, 10,000)	16,646	C+	4(2)	2	3,4
	Sept.	Roosevelt	821	C+	3	0	0
		Black Hills, Wyo	473	C+	1	0	0
	Oct.	Arapaho	167	C+	1	0	0
		GM-Uncompaghre	277	C+	1	0	0
		Black Hills	2,000	C+	3	3	2
1966	July	Pike	350	C+	4(1)	9	0
		Medicine Bow	540	C+	4(1)	0	0
	Sept.	Roosevelt	470	C+	2(1)	0	0
	Oct.	San Isabel	400	C+	2	0	0
1968	May	Black Hills	604	C+	1	0	0
	June	Arapho	591	C+	1(1)	0	0
		Pike	269	C+	1(1)	0	0
		San Juan	349	C+	1(1)	0	0
		White River	305	C+	4(1)	0	0
1970	April	San Isabel	435	E	1	0	0
	Aug.	Bighorn	4,505	F	1	1	3
		Shoshone	1,209	F	1	1	2
	Nov.	San Isabel	350	E	1	0	0

1/ Numbers in parenthesis indicate those fires which went into extra periods.

Exhibit B7. (cont.)

Region 3

Year	Month	Forest	Acres	Tot. # Fires class	: # 1/	# Multi-Div. Fires	Estimated # Div. Units
1960	April	Coronado	1,286	C+	5	5	2
	June	Coronado	14,587	C+	17(8)	8	5
		Kaibab	8,504	C+	1(1)	1	4
		Tonto	161	C+	4	0	0
		Gila	112	C+	2	0	0
		Santa Fe	518	C+	1	0	0
	July	Prescott	213	C+	3	0	0
		Tonto	229	C+	4(1)	0	0
	Aug.	Prescott	689	C+	1(1)	0	0
		Tonto	100	C+	3(2)	0	0
	Sept.	Coronado	356	C+	1	0	0
		Santa Fe	100	C+	1	0	0
1961	April	Coronado	733	C+	3(1)	1	2
	May	Apache	270	C+	1	0	0
		Coronado	283	C+	1(1)	0	0
	June	Apache	405	C+	5(2)	0	0
		Coronado	11,967	C+	21(6)	2	4,3
		Prescott	112	C+	5(2)	0	0
		Tonto	3,443	C+	10(3)	3	3
		Cibola	122	C+	1	0	0
		Gila	105	C+	1	0	0
	July	Coronado	827	C+	7(2)	0	0
		Cibola	1,086	C+	2	0	0
1966	April	Tonto	365	C+	1	0	0
		Gila	606	C+	3(3)	0	0
	May	Gila	149	C+	2	0	0
		Santa Fe	422	C+	1	0	0
	June	Coconino	821	C+	1	0	0
		Coronado	2,258	C+	12(2)	[illegible]	3
		Kaibab	492	C+	2(1)	0	0
		Tonto	24,467 (9,000;8,000;5,000)	C+	10(3)	3	4,4,3

Exhibit B7. (cont.)

Region 3

Year	Month	Forest	Acres	Tot. class	# Fires : # 1/	# Multi-Div. Fires	Estimated # Div. Units
	July	Coronado	129	C+	4	0	0
		Tonto	201	C+	3	0	0
	Sept.	Kaibab	262	C+	1	0	0
	Nov.	Coconino	219	C+	1	0	0
1968	April	Coronado	326	C+	2	0	0
	May	Gila	113	C+	1	0	0
		Lincoln	168	C+	1	0	0
	June	Apache	537	C+	2(1)	0	0
		Coronado	25,742	C+	15(6)	4	4,3,3,2
		Prescott	290	C+	2	0	0
		Sitgreaves	5,853	C+	1	1	2
		Tonto	1,222	C+	3(3)	3	2
		Santa Fe	322	C+	2(1)	0	0
	July	Coconino	200	C+	1	0	0
		Coronado	230	C+	2(2)	0	0
		Cibola	130	C+	3	0	0
	Sept.	Coronado	1,448	C+	5(2)	2	2
		Apache	142	C+	2(2)	0	0
		Gila	135	C+	2(2)	0	0
	Oct.	Coronado	152	C+	3	0	0
	Nov.	Coronado	1,000	C+	2	2	2
1970	April	Coronado	1,067	C+	4	0	0
		Tonto	689	C+	3	0	0
		Gila	800	C+	2	0	0
	May	Coronado	2,878	C+	4(1)	1	3
	June	Coronado	1,434	C	10	0	2
				E	2	1	
		Tonto	148	C	1	0	0
	July	Coronado	843	C	9	0	0
				D	1	0	

Exhibit B7. (cont.)

Region 3

Year	Month	Forest	Acres	Tot. # Fires class :	# 1/	# Multi-Div. Fires	Estimated # Div. Units
	July	Tonto	14,882	C	8	0	6
				D	2	0	
				E	1	1	
				F	2	2	
				G	1	1	
	Aug.	Coronado	164	D	1	0	0
		Tonto	269	C	7	0	0
	Sept.	Tonto	343	E	1	0	0
		Gila	1,453	C	2	0	2
				F	1	1	

Exhibit B7. (cont.)

Region 4

Year	Month	Forest	Acres	Tot. class	# Fires #	# Multi-Div. Fires	Estimated # Div. Units
1960	July	Boise	12,426	G	1	0	0
		Boise	2,740	F	1	1	2
		Sawtooth	9,042	G	1	1	4
		Boise	652	E	1	0	0
		Toiyabe	527	E	1	0	0
		Payette	11,967	G	1	1	5
		Unita	505	E	1	0	0
		Targhee	1,340	F	1	1	2
		Boise	950	E	1	0	0
		Boise	6,880	G	1	1	4
		Targhee	4,585	F	1	1	3
		Salmon	1,156	F	1	1	2
		Humbolt	400	E	1	0	0
		Payette	2,020	F	1	0	0
		Unita	415	E	1	0	0
	Aug.	Humbolt	320	E	1	0	0
		Caribou	1,275	F	1	1	2
		Wasatch	1,320	F	1	1	2
	Sept.	Sawtooth	480	E	1	0	0
		Payette	460	E	1	0	0
1961	June	Bridger	404	E	1	0	0
		Dixie	450	E	1	0	0
		Boise	5,736	G	1	1	4
		Wasatch	450	E	1	0	0
		Boise	1,410	F	1	1	2
		Toiyabe	9,061	G	1	1	5
	July	Unita	491	E	1	0	0
		Sawtooth	1,310	F	1	0	0
		Wasatch	375	E	1	0	0
		Boise	620	E	1	0	0
		Payette	920	E	1	0	0
		Payette	1,585	F	1	1	3
		Challis	1,320	F	1	1	2
	Aug.	Sawtooth	425	E	1	0	0
		Salmon	2,030	F	1	1	2
		Payette	3,030	F	1	1	3
		Boise	480	E	1	0	0
		Salmon	1,960	F	1	1	2
		Sawtooth	1,700	F	1	0	0

Exhibit B7. (cont.)

Region 4

Year	Month	Forest	Acres	Tot. class :	# Fires #	# Multi-Div. Fires	Estimated # Div. Units
1966	May	Salmon	644	E	1	0	0
	June	Toiyabe	1,207	F	1	1	2
		Humbolt	550	E	1	0	0
	July	Sawtooth	790	E	1	1	2
		Ashley	350	E	1	0	0
		Challis-Targhee	6,400	G	1	1	5
		Salmon	402	E	1	0	0
		Sawtooth	475	E	1	0	0
		Sawtooth	3,155	F	1	1	3
		Toiyabe	800	E	1	0	0
		Caribou	1,000	F	1	1	2
		Challis	1,500	F	1	1	2
	Aug.	Caribou	417	E	1	0	0
		Boise	1,250	F	1	0	0
		Humbolt	3,500	F	1	1	2
		Boise	12,706	G	1	1	5
		Caribou	775	E	1	0	0
		Humbolt	1,950	F	1	1	2
		Humbolt	5,400	G	1	1	3
		Challis	305	E	1	0	0
		Salmon	420	E	1	0	0
		Sawtooth	66,550	G	1	1	5
		Caribou	1,587	F	1	1	2
	Sept.	Payette	5,500	G	1	1	3
1967	June	Salmon	335	E	1	0	0
	July	Fishlake	576	E	1	0	0
		Dixie	1,512	F	1	1	2
		Salmon	542	E	1	0	0
		Toiyabe	1,541	F	1	1	2
		Humbolt	340	E	1	0	0
1968	Aug.	Caribou	620	E	1	0	0
1970	May	Manti-Lasal	404	E	1	0	0
	Aug.	Payette	1,040	F	1	1	2
	Sept.	Humbolt	800	E	1	0	0

Exhibit B7. (cont.)

Region 5

Year	Month	Forest	Acres	Tot. class	# Fires : #	# Multi-Div. Fires	Estimated # Div. Units
1960	June	Los Padres	405	E+	1	0	0
		Angeles	1,670	E+	1	1	2
		Cleveland	460	E+	1	0	0
		San Bernardino	607	E+	1	0	0
	July	Angeles	66,013	E+	6	4	8
		Cleveland	2,043	E+	1	1	2
		Los Padres	11,717	E+	1	1	4
		San Bernardino	1,501	E+	1	1	2
		Sequoia	1,101	E+	1	1	2
		Stanislaus	2,032	E+	1	1	3
		Six Rivers	407	E+	1	0	0
	Aug.	San Bernardino	5,505	E+	1	1	3
		Tahoe	79,027	E+	4	4	11
		Plumas	7,134	E+	3	3	4
		Shasta-Trinity	625	E+	1	0	0
		Six Rivers	300	E+	1	0	0
	Sept.	Angeles	1,293	E+	1	1	2
		Inyo	2,490	E+	1	1	3
		Modoc	3,900	E+	1	1	3
	Oct.	Shasta-Trinity	585	E+	1	0	0
1961	June	Angeles	4,910	E+	2	0	0
		Inyo	5,486	E+	1	1	3
		Sequoia	417	E+	1	0	0
		Modoc	682	E+	1	0	0
	July	Los Padres	300	E+	1	0	0
		San Bernardino	1,122	E+	2	0	0
		Sierra (11,000;8,000)	19,960	E+	2	2	4,4
	Aug.	Sequoia	2,484	E+	1	1	3
		Klamath	1,091	E+	1	1	2
		Six Rivers	3,012	E+	2	2	3
	Sept.	Cleveland	6,748	E+	1	1	4
	Oct.	Angeles	752	E+	1	0	0
		Los Padres	2,282	E+	1	1	3
		Sequoia	1,070	E+	1	1	2
		Sierra	2,000	E+	1	1	3
	Nov.	Angeles	1,300	E+	1	0	0

Exhibit B7. (cont.)

Region 5

Year	Month	Forest	Acres	Tot. # Fires class :	#	# Multi-Div. Fires	Estimated # Div. Units
1966	June	Los Padres	91,962	E+	2	2	9
		San Bernardino	1,967	E+	1	1	2
		Sequoia	3,235	E+	2	2	4
	July	Cleveland	818	E+	1	0	0
		Inyo	380	E+	1	0	0
		Los Padres	3,430	E+	1	1	3
		Lassen	240	E+	1	0	0
		Plumas	2,740	E+	1	1	3
		Shasta-Trinity	446	E+	1	0	0
	Aug.	Lassen	410	E+	1	0	0
		Medocino (18,000;4,000)	22,728	E+	2	2	5,3
		Tahoe	800	E+	1	1	2
	Sept.	Angeles	1,360	E+	1	1	2
		San Bernardino	1,370	E+	1	1	2
		Sequoia	1,889	E+	1	1	2
		Sierra	5,201	E+	2	2	4
		Klamath	12,220	E+	1	1	4
		Lassen	740	E+	1	0	0
		Plumas	2,100	E+	1	1	3
	Oct.	Inyo	300	E+	1	0	0
	Nov.	Angeles	1,436	E+	1	1	2
		Lassen	1,490	E+	2	2	2
1968	May	Los Padres	350	E+	1	0	0
	June	Angeles	47,100	E+	2	2	9
		Los Padres	2,871	E+	1	1	3
	July	Angeles	300	E+	1	0	0
		Sequoia	635	E+	1	0	0
		Sierra	515	E+	1	0	0
		Stanislaus	300	E+	1	0	0
	Aug.	Angeles	18,460	E+	1	1	5
		Cleveland	800	E+	2	0	0
		Sierra	300	E+	1	0	0
		Shasta-Trinity	435	E+	1	0	0
		Stanislaus	500	E+	1	0	0

Exhibit B7. (cont.)

Region 5

Year	Month	Forest	Acres	Tot. class	# Fires #	# Multi-Div. Fires	Estimated # Div. Units
1968	Sept.	Angeles	3,340	E+	2	2	3
		San Bernardino	10,040	E+	2	2	4
		Stanislaus	300	E+	1	0	0
	Oct.	Klamath	3,400	E+	2	2	3
1970	May	Sequoia	330	E	1	0	0
	June	Angeles	1,760	F	1	0	0
	July	Sequoia	1,350	F	1	1	2
	Aug.	Plumas	1,041	F	1	1	2
		Shasta-Trinity	950	E	1	1	2
		Los Padres	1,206	F	1	1	2
	Sept.	Cleveland	122,560	F	1	1	8
				G	2	2	
		Angeles	9,815	E	1	1	4
				F	2	2	
				G	1	1	
		Los Padres	24,000	G	1	1	6
		San Bernardino	10,491	F	1	1	4
				G	1	1	
		Sequoia	17,120	G	2	2	6,4
	Nov.	San Bernardino	54,550	F	1	1	7
				G	1	1	

Exhibit B7. (cont.)

Region 6

Year	Month	Forest	Acres	Tot. # Fires class :	#	# Multi-Div. Fires	Estimated # Div. Units
1960	July	Fremont	1,358	E+	2	2	2
		Malheur	2,717	E+	1	1	3
		Okanogan	494	E+	1	0	0
		Umatilla	13,873	D	7	6	4
				E+	6	6	
		W. Whitman	44,702	D	6	0	6,3,2
		(28,000;10,000;6,000)		E+	10	3	
	Aug.	Ochoco	652	E+	2	0	0
		W. Whitman	2,567	E+	3	3	3
	Sept.	Snoqualmie	1,721	E+	1	1	2
1961	June	Wenatchee	3,598	E+	1	1	3
	July	Deschutes (1,000;400)	1,478	E+	2	1	2,1
		Umatilla	8,122	D	1	0	4
				E	2	2	
		W. Whitman	263	E+	1	0	0
	Aug.	Deschutes	710	E+	1	1	2
		Ochoco	1,000	E+	2	0	0
		Umpqua	425	E+	1	0	0
		W. Whitman	398	E+	2	0	0
		Wenatchee	736	D	1	0	0
				E	2	0	
1966	June	Siskiyou	261	E+	1	0	0
	July	Fremont	791	E+	1	1	2
	August	Fremont	5,973	E+	1	1	3
		Mt. Hood	1,149	E+	1	1	2
		W. Whitman	708	E+	1	0	0
		Wenatchee	1,449	E+	1	1	2
1967	July	Olympic	550	E+	1	0	0
	Aug.	Gifford Pinchot	348	E+	1	0	0
		Mt. Baker	315	E+	1	0	0
		Snoqualmie (3,000;2,000)	5,475	E+	2	2	5

Exhibit B7. (cont.)

Region 6

Year	Month	Forest	Acres	Tot. # Fires class	: #	# Multi-Div. Fires	Estimated # Div. Units
1967	Aug.	W. Whitman	300	D	4	0	0
		Willamette (8,000;4,000)	12,350	E	2	2	4,3
1968	July	Deschutes	1,153	E+	3	3	2
		Ochoco	3,174	D	1	1	4
				E+	2	0	0
		Wenatchee	1,960	D	1	0	2
				E+	1	1	
	Aug.	Okanogan	3,898	E+	3	1	3
		Wenatchee	24,520	E+	2	1	6
1970	July	Okanogan (300;300;300;300; 1,000;1,000;6,000)	9,214	E	4	0	0
				F	2	2	2,2
				G	1	1	4
		Siskiyou	487	E	1	1	2
		Wenatchee	15,697	E	1	0	4
				G	1	1	
	Aug.	Okanogan	14,316	G	1	1	2
		Wenatchee	94,000	D	3	0	0
				E	2	0	0
				G	4	4	5,2,2,4

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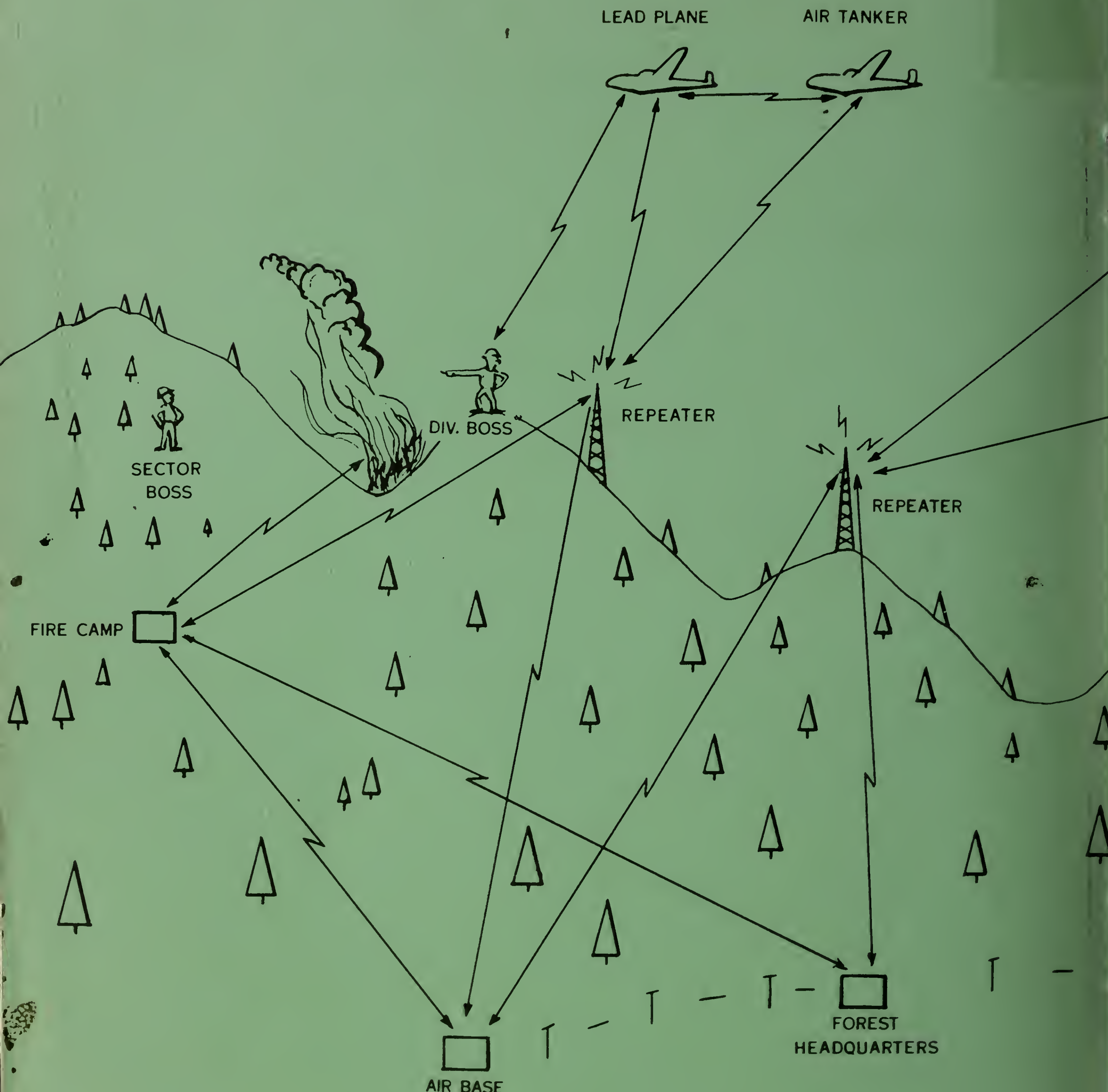
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AIR TANKER
DIV. BOSS
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